POWER

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HE understood the grades of coal
And knew its varied nomenclature,
But couldn't state, to save his soul,
The facts about its real nature.
To him it meant the smutty stuff
Whose burning made the smoke-clouds lower;
Whose heaps seemed never great enough
To furnish the required power.

He yearned to find some simple scheme
To make his fires burn the stronger
And turn more water into steam,
Yet make his fuel bills no longer.
And so he proved a shining mark
For every glib, persuasive faker,
A prey to charlatan and shark
And every secret-compound maker.

They sold him powders, which, they said,
The value of his coal would double,
And subtle liquids that, if spread,
Would burn the ashes with no trouble.
They met his every whim and need
With panaceas and devices,
All highly praised and guaranteed,
And billed at most outrageous prices.

He tried them out, at first with zeal,
Then with suspicion swiftly gaining,
For at each failure he could feel
His hopeful, buoyant spirit waning.
And so, while schemes grew dead and dull,
And while his flattened purse grew flatter,
This truth seeped slowly through his skull
And settled in his grayish matter:

* * *

PREVENTING coal waste doesn't lie
In nostrums, with their claims inspiring,
But in the men who can apply
The rules of economic firing.

Singer Plant at South Bend

By Thomas Wilson

SYNOPSIS—The concentration of two individual plants supplying power mechanically into one modern station with electrical distribution of power effected a large saving in coal and reduced the labor as well as the various losses common to a steam plant. The feature of the new plant is the method of collecting the sawdust and controlling closely the feed to the boiler furnaces. Per pound of this fuel the evaporation runs as high as 5.5 lb. of water from and at 212 deg. F.

South Bend, Ind., has long been the home of one of the large branch factories of the Singer Manufacturing Co. Here all cabinet work and stand part operations are performed from the raw material to the finished product, the capacity being 8,000 sewing-machine cabinets and 1,000 stands per day. The site covers 76.5 acres, and 31 acres is the floorage area in the various buildings. To supply these works with steam for heating and factory use, compressed air, water for domestic service, fire protection, drinking, and for the operation of elevators and hydraulic presses, and with electricity for power and light and electric locomotives required a plant of some magnitude.

FIG. 1. EXTERIOR OF POWER PLANT; COOLING TOWERS IN FOREGROUND

These services had been supplied by three practically distinct plants—the north and south boiler and engine plants and the foundry plant. The first two adjoined the machinery building, which contains practically all the large wood-working machines and is responsible for the major portion of the power load. All the machines in this building were belted to lineshafting. Two Corliss engines of 1,000 hp. each—one in the north engine room and the other in the south engine room—were belted direct to the jackshafts in the basement. From these shafts diagonal belt drives were carried up in two steel towers to the various floors. On the ceiling of each story two main lineshafts were carried throughout the length of the building, one on either side of a central aisle.

In the cabinet and finishing buildings the lineshafting was all driven by direct-current motors which obtained their power from generating units in the north engine room. The various pumps, air compressors, high-duty pumping engines and like equipment were in small buildings adjoining the north and south plants. The foundry plant, some 2,000 ft. distant, served a small group of buildings having comparatively little power demand.

In the three boiler plants there was a total of 3,016 boiler horsepower in 18 units consisting mostly of small water-tube boilers provided with plain grates and arranged for burning coal and sawdust. All the boilers were equipped with steam jet blowers.

The engine units had an aggregate capacity equivalent to 2,325 kw. There were the two 22&44x48-in. Corliss engines in the north and south plants, which operated condensing, and in addition there were two vertical engines driving 300-kw. generators, one 50-kw. and one 100-kw. generating units, the latter being driven by simple noncondensing engines. The foundry was supplied with light and power by a 75-kw. generator driven by a small high-speed engine. All three plants were provided with the usual complement of feed-water heaters, boiler-feed pumps, washout pumps and miscellaneous apparatus.

In all buildings other than the machinery building power was supplied by 250-volt direct-current motors. In the cabinet-building section these motors were directly connected to the ends of the lineshafting. In the majority of cases the shafting ran at approximately 460 r.p.m.

All the buildings in the group were heated by vacuum systems using the exhaust steam from the engines and the auxiliaries. In summer the engines were operated condensing and in extremely cold weather practically the entire combined engine and auxiliary exhaust was utilized. At night when the engine and generating units were shut down the heating was cared for by live steam.

Water for domestic and drinking purposes was obtained from three 8-in. wells approximately 110 ft. deep, and the supply for other uses from four large cross-connected surface wells. The fire pumps were located below ground and adjoining one of the large wells, and the condenser circulating pumps drew water from two of the smaller wells and discharged it to the sewer.

The foregoing is an outline of the old arrangement. Some three years ago the firm of Neiler, Rich & Co., consulting engineers, of Chicago, was called in to analyze the situation with a view to modernizing the power plant, increasing flexibility of operation and improving the economy. It was decided to erect a new central plant to replace the older installations scattered about the works. Some of the pumps, air compressors and such machinery as could be used to advantage were to be installed in the new plant, but for the most part it was to have modern and more economical equipment. A change was also made from mechanical to electrical transmission.

One of the important features entering into the design of the new plant was the variable fuel supply. Owing to the character of the work large amounts of wood cuttings and sawdust were available. Of the total wood fuel about 25 per cent. was wood cuttings, small blocks and veneer, the remainder being dry-kilned hardwood sawdust. In the old plant running under normal conditions the wood fuel was sufficient to run the boilers throughout the entire working period of ten hours with a surplus available for night use. During the heating season, however, it was necessary to use coal at night and also during the inventory periods in January and July. Between 18,000 and 19,000 tons of coal were used per year.

The water supply was another feature governing the selection of equipment. It was deemed advisable to conserve the water for fire protection, so cooling towers were installed to care for the condenser circulating water. The old Corliss engines, when operated condensing, utilized about 1,335 gal. of water per minute and as this was discharged to the sewer, the waste was enormous.

Ten years before the investigation the water had been 6 ft. below grade. During the intervening period the average level had declined from 8 to 13 ft., so that under extreme conditions the water level was 19 ft. below grade, and the high suction lift naturally prevented the satisfactory operation of many of the pumps. In the new plant arrangements were made to lift the water from the 100-ft. deep wells by air and deliver it into a large tank, from which it could flow by gravity to the domestic-service pumps.

Providing steam for heating was one of the major considerations inasmuch as the supply for the 140,000 sq.ft. of radiation required in extreme weather between 1,200 and 1,400 boiler horsepower. Another interesting problem was the selection and arrangement of the wiring, shafting and motor drives to meet existing conditions and at the same time conserve the initial investment and maintain a low operating cost.

The power-house building is of specially substantial construction and pleasing appearance. The boiler, pump and condenser rooms are on the ground level there being no basement excepting a small one under the front of the boilers. The turbine floor is 16 ft. above grade. The boilers are set with re-pressed buff Kittanning brick and the same brick is used for the high wainscoting around the boiler room. The pump room has cement wainscoting painted green, the brickwork above being painted cream. The turbine-room floor is of dark red tile, while the wainscoting is of sea-green tile, the walls being enameled light cream. At one end of the turbine room is the engineer's office in connection with which is a spacious file room for records, a laboratory and engineer's toilet.

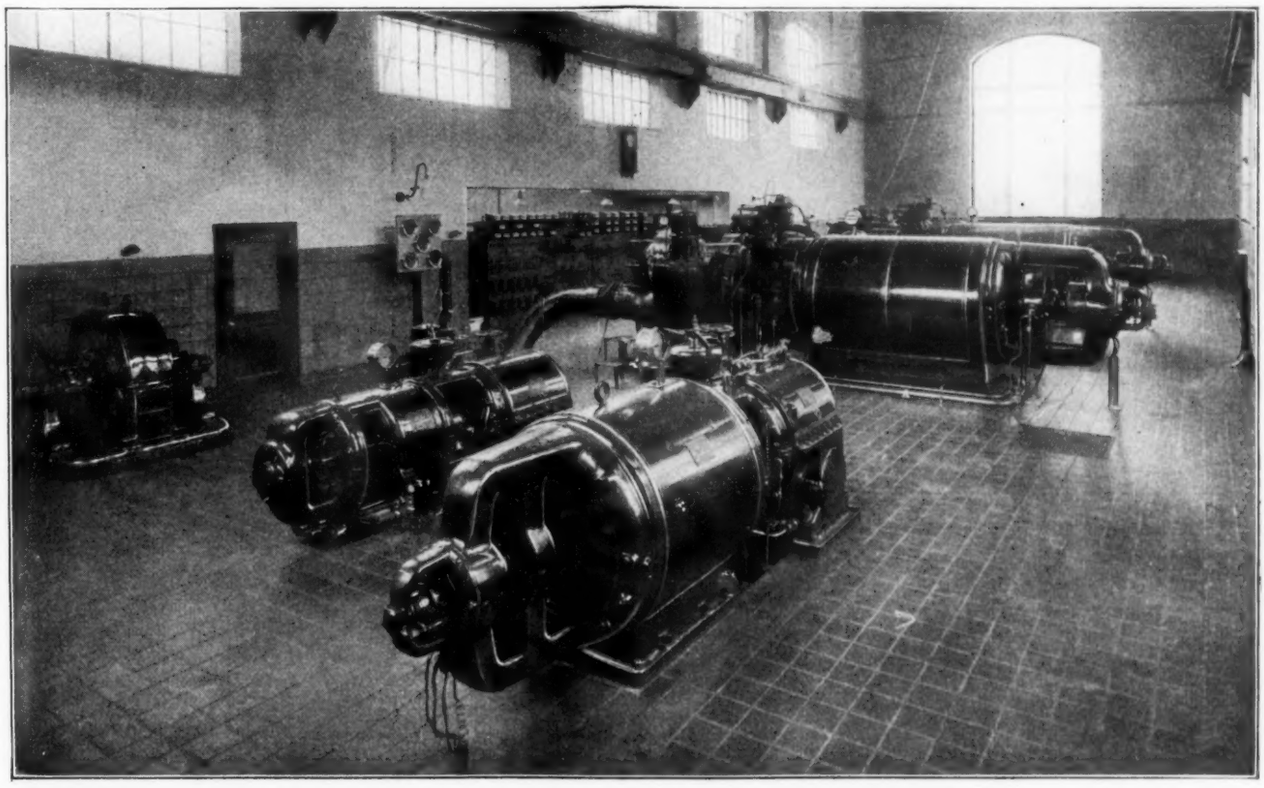


FIG. 2. VIEW IN THE TURBINE ROOM AT SINGER PLANT

Conditions were right for bleeder turbines, and two four-stage machines, each rated at 3,438 kv.-a., or 2,750 kw. at 80 per cent. power factor, were installed. The turbines are directly connected to 480-volt three-phase 60-cycle generators with exciters mounted on the mainshafts. In the preliminary estimate it had been figured that the turbine would save over the engines then installed 37,600,000 lb. of steam per year, the assumed conditions of turbine operation providing sufficient steam for heating requirements. Owing to the concentration less labor would be required, there would be less loss due to condensation, fewer repairs, no cylinder oil and less engine oil and other supplies such as packing. With a modern boiler plant designed to burn wood fuel more efficiently and to conserve the supply so that comparatively little coal would be needed, the annual saving in operating expense was estimated at $36,600. At this rate the installation is not long paying for itself.

Table 1 shows the amount of steam used per hour by the turbines at different loads and the steam which can be extracted. The steam consumptions given are based on a steam pressure of 175 lb. with 125 deg. superheat. At

TABLE 1. STEAM EXTRACTION AT DIFFERENT LOADS

Load, Kw.	Extraction, Lb. Steam per Hr.	Total Flow, Lb. Steam per Hr.
1,000	30,800	32,800
1,500	41,500	44,200
2,500	50,000	64,200

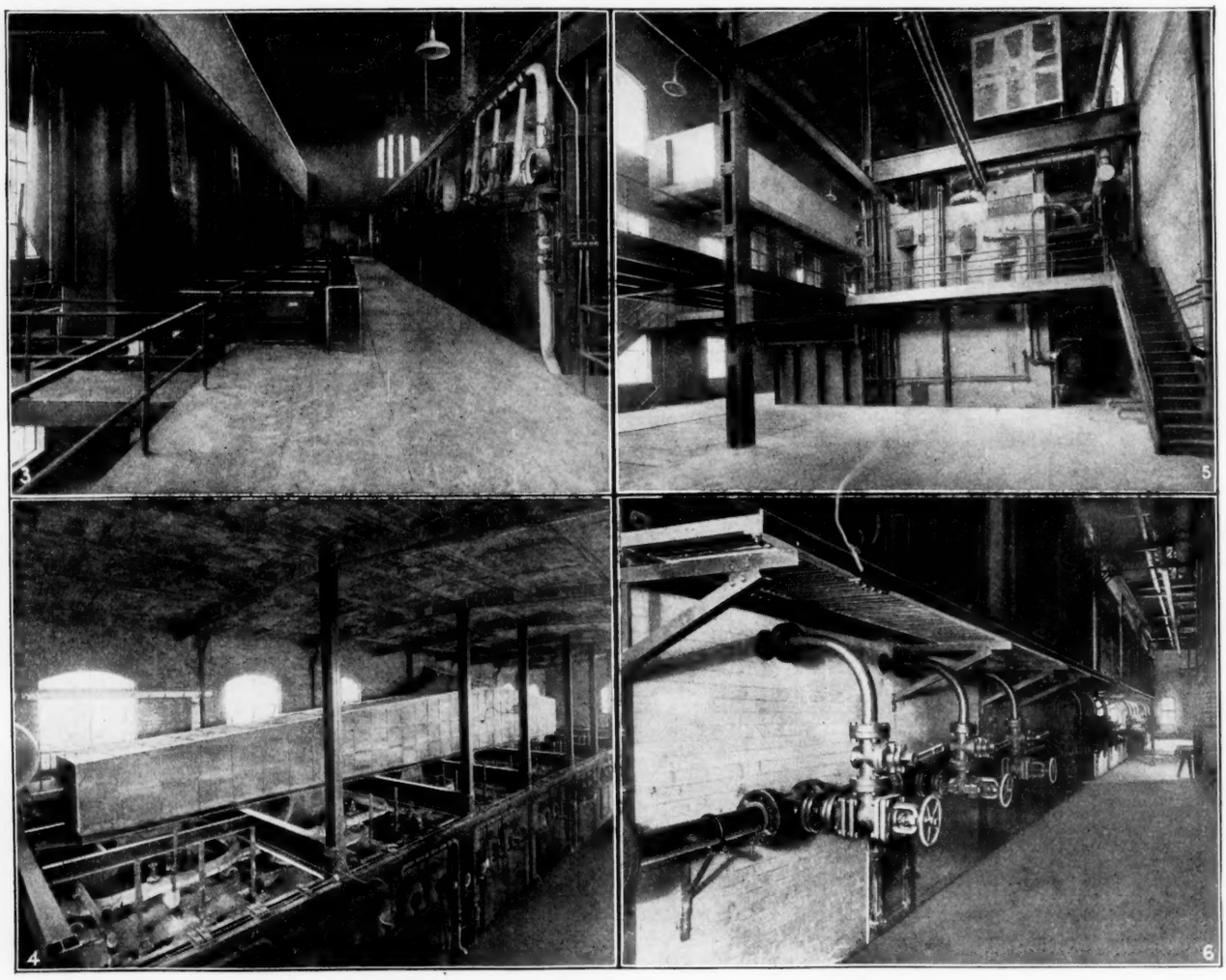
2,500 kw. the expected normal electrical load on the plant, the possible steam extraction for heating amounts to 50,000 lb., which will easily supply in extreme weather the 140,000 sq.ft. of radiation contained in the works. In other words, with one turbine running at nearly its rated capacity sufficient steam may be extracted to supply the demands of the entire heating system.

The exhaust side of the second stage has an opening for extracting the steam and a gridiron valve for controlling the amount, this valve being operated automatically by a steam piston, pilot valve and diaphragm regulator. In the 24-in. heating main a back pressure of approximately 2½-lb. gage is maintained.

In summer when but little steam is used in the heating system, the exhaust from the noncondensing auxiliaries not required by the feed-water heaters is automatically fed back into the third and fourth stages of the turbine. In this way some power is derived from the auxiliary exhaust steam before it passes to the condenser. A valve on the extraction line controlled by the overspeed regulator prevents the turbine from running away under light loads and low-pressure steam.

The machines have water-cooled bearings, oil-circulating pumps and coolers, Frahm vibrating speed indicators, and an overspeed release set at 3,900 r.p.m. As the water comes from the bearings it is passed through cooling coils in the drinking-water tank and returned to the machine. It is thus circulated continuously in a closed circuit and trouble from lime or scale is avoided. The amount of drinking water is sufficiently large, so that there is no appreciable rise in temperature. The lubricating oil is circulated through small closed heaters, or rather coolers in this case, as water is passed through counter-current to the oil and the latter maintained at the proper temperature. Oil filters with pumping equipment, gravity tanks, distributing piping and fountains have been installed.

The condensers serving the units are of the two-pass surface type containing 6,500 sq.ft. of surface in 1-in. brass tubes. This reduces to 2.36 sq.ft. of surface per kilowatt of rating at 80 per cent. power factor, and at full load calls for a condensation of approximately 6 lb. of steam per square foot of surface per hour. The cir-



FIGS. 3 TO 6. VIEWS OF BOILER ROOM AND FUEL-HANDLING PLANT

Fig. 3—Sawdust tanks and screw conveyors feeding through furnace roofs. Fig. 4—Looking down on top of boilers. Fig. 5—Side view, showing relative positions of tanks, furnaces and boilers. Fig. 6—View at back of boilers

culating and condensate pumps are motor-driven centrifugals, while the dry-vacuum pumps are of the center-crank and flywheel type. This distribution between motor-driven and steam auxiliaries maintains the heat balance under average operating conditions. Under light loads the surplus exhaust, as previously stated, is fed back into the main turbine.

To conserve the condenser cooling water, two cooling towers have been provided. Each tower is provided with four 8-ft. motor-driven fans running at 300 r.p.m. and is designed to cool 2,660 gal. of water per minute from a temperature of 100 to 85 deg. F. This guarantee was based on an outside temperature of 70 deg. and 70 per cent. relative humidity.

In addition to the two large turbines, there is a 375-kv.-a. machine driven by a two-stage noncondensing turbine and used to care for night and Sunday loads. A 75-kw. turbine-driven exciter has also been installed as a reserve. A 200-kw. synchronous converter supplies 550-volt direct-current for the electric locomotives used in the yards.

An air washer has been provided in connection with the turbine air supply. This has a capacity of 25,000 cu.ft. of air per minute.

In the old plant the electrical service for lighting and motors had been 250-volt direct-current, trolley service for the electric locomotives being 250-volt direct current supplied by a separate machine. After careful consideration it was decided to do away with all of the direct-current apparatus and provide 440 three-phase 60-cycle generating equipment. The trolley service was changed over to 500 volts direct-current, which is supplied by the rotary converter previously mentioned. For lighting, the supply from the station bus is stepped down to 110 volts.

The problem of driving the individual machines in the factory presented certain difficulties. It was impractical to furnish motors for each machine and in consequence various sections of the lineshafting were arranged for group driving. The question of directly connecting the motors to the ends of shafting and running the latter at approximately 720 r.p.m. was considered, but conditions were not suitable for this, and high-speed motors with relatively high power factors seemed preferable, so eventually the motors were connected by chain drives to the individual lineshafts. Incidentally this obviated the necessity of changing the majority of the pulleys.

In the factory there is a total of 150 motors having a rated capacity of 2,450 hp., the sizes ranging from 15 up to 50 hp. In addition there are four 180-hp. synchronous motors for driving the large fans that collect the sawdust, and approximately 300 hp. in motors installed in connection with the power house for driving circulating pumps, hotwell pumps, fans and other miscellaneous apparatus. The total connected motor load then is approximately 3,500 hp., with the maximum lighting load approximating 250 kw. With the exception of the four motors driving the sawdust-collecting fans, all the motors are of the induction type. Aside from a most complete and convenient arrangement of piping and modern construction of the best type, the boiler room is provided with a unique and particularly effective system for handling and feeding the sawdust into the furnaces. The boiler room contains six 520-hp. water-tube boilers, each of 5,200 sq.ft. of heating surface and stationary grates having an area of 90 sq.ft., the proportion of heating surface to grate area being 57.8 to 1. The operating pressure is 175 lb. gage and the superheat 125 deg. The twin furnaces extending 14 ft. 3 in. in front of each boiler provide for long flame travel and efficient combustion of the sawdust. Each is 5 ft. 3½ in. wide by 8 ft. 6 in. long, the center wall between the two being 24 in. thick and the side walls 21 in. The grates are of the herringbone pattern with the dumping section next the bridge-wall. Deflection arches were originally provided between the bridge-wall and the first flame wall, but these have been removed because of the excessive temperature produced, and there is now free passage for the gases from the furnace to the tubes.

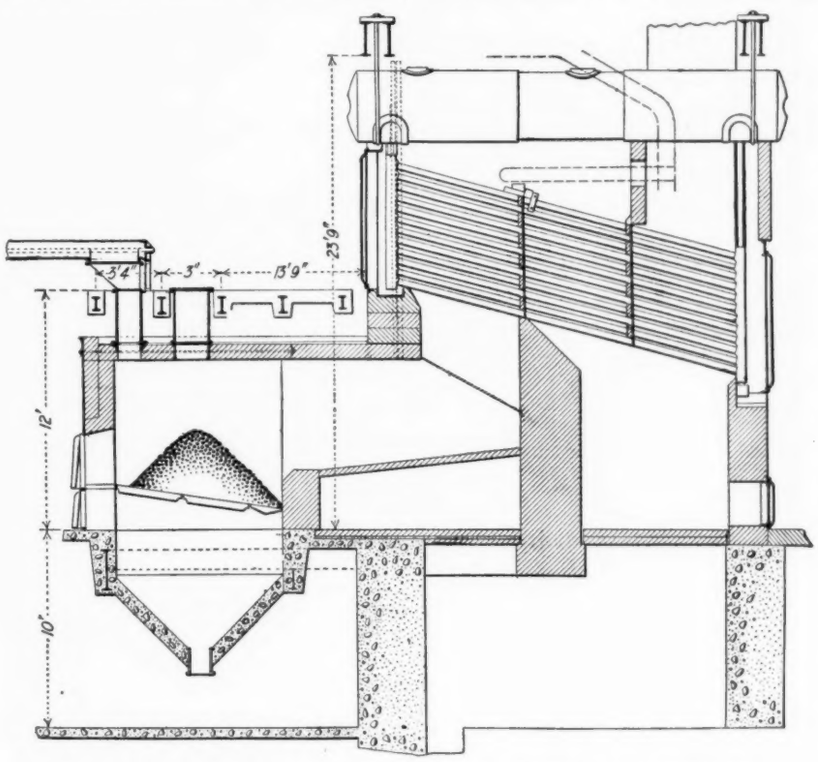


FIG. 7. SECTIONAL VIEWS THROUGH BOILER AND FURNACE

At the top of the furnace and near the front of each section provision is made for the introduction of the sawdust and in addition a large opening is provided for the wood cuttings and blocks which are transported in trucks to the firing floor and dumped directly into the furnace. Both of the openings are provided with cast-iron necks which pass up through the firing floor immediately above the furnaces. This floor extends the full length of the boiler room at a level just below the bottom of the front tube doors of the boilers. By means of a runway the firing floor is connected with the second floor of the machinery building, in which practically all the blocks and wood cuttings are obtained. The chief dimensions of the furnace are given in Fig. 7.

As will be seen in the illustrations, the sawdust is fed to the boiler furnaces independently of the coarser material. The collector system consists of four steel towers outside the machinery building. All the various trunk ducts are carried into these main towers, the suction being furnished by eight large motor-driven fans, two for each tower. Four smaller fan equipments in series, each somewhat larger than its predecessor, remove the sawdust which drops into the collectors and deliver it successively from tower to tower and finally discharge it into the collector located above the boiler room. It is claimed that this new system shows a material saving in power over the former method of removing the sawdust from each individual collector and blowing it directly to storage at the boiler house.

Upon leaving the collector above the boiler room the sawdust drops through chutes into a horizontal scraper, or flight conveyor. Through gates in the conveyor bottom the sawdust drops into six steel tanks, one for each boiler. As soon as the first tank is filled the gate may be closed, or in any event the sawdust will automatically pass on and drop into the next opening. These tanks are on a level with the firing floor. They are oval at the top and flare out at the bottom so that there will be no difficulty from the sawdust arching and lodging in the upper part.

At the bottom each tank has two screw conveyors which carry the sawdust over and drop it into the chutes on top of the boiler furnaces. The screws are driven by friction disks and pulleys on a shaft running behind the tanks, the shaft being driven by a small vertical engine. Varying the speed of the engine will change the speed of all screw conveyors, but as the requirements of each furnace may not be the same, individual adjustment of the rate of feed can be made by changing the position of the friction pulley on the disk drive.

With the usual method of feeding sawdust from the collector system to the furnace by an air blast, the great disadvantage is the unevenness of the fuel supply. At times there is an excess of air and light fuel charge, while again the fuel is fed too fast and insufficient air is supplied. The method just described obviates these objections and accurately controls both fuel and air. In addition to the fire-doors on the furnaces, dampers have been provided near the intake chutes, so that plenty of air may be introduced above the fire.

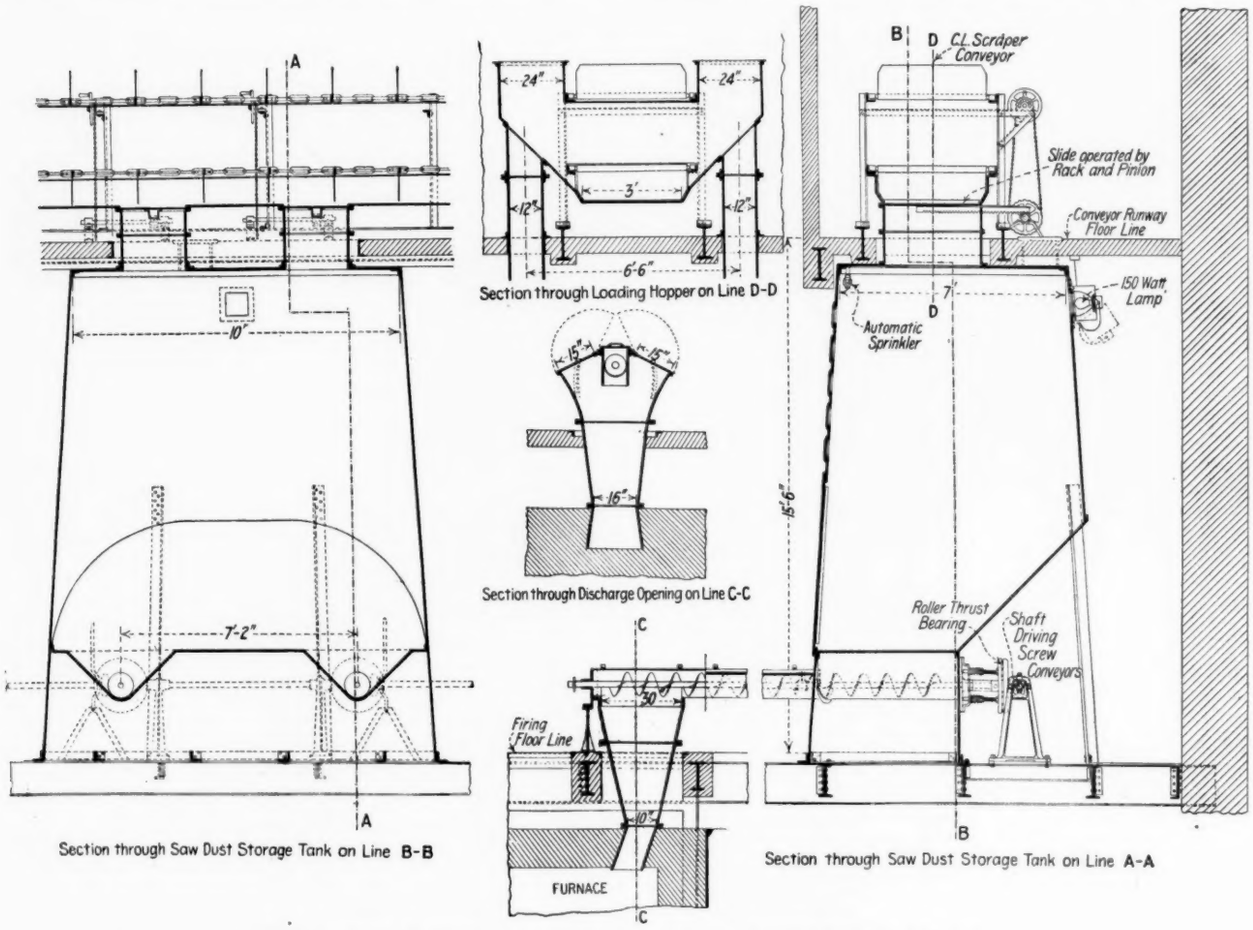


FIG. 8. THE SAWDUST TANKS AND FLIGHT CONVEYOR IN DETAIL

Draft is supplied by a reinforced-concrete stack rising 253 ft. above the foundation and lined with firebrick for 105 ft. The outside diameter at the base is 21 ft. 3¼ in. with an internal uniform diameter of 12 ft. From the center of the stack the breeching extends 72 ft. in one direction, serving two batteries of boilers, and 38 ft. in the other, serving one battery. When the future battery of two boilers is installed, the stack will be located centrally, serving four boilers on either side. Per 1,000 sq.ft. of boiler heating surface, there is 4.45 sq.ft. of breeching, 3.33 sq.ft. of stack and 17.3 sq.ft. of connected grate area.

Each boiler has two steam-supply lines, one for superheated and the other for saturated steam, the latter for supplying dry kilns. Full protection is afforded by stop

valves and in addition triple-duty automatic valves. A feature is the location of the control of these valves at a central point in the pump room to facilitate the prompt closing of any of the steam circuits desired. The dampers

TABLE 2. ANNUAL COAL CONSUMPTION

Year	Tons, 2,000 Lb.	Year	Tons, 2,000 Lb.
1910	25,450	1913	18,372
1911	18,771	1914	18,525
1912	19,163	1915	14,505

are operated from the boiler front through worm-and-quadrant gears. Ashes are removed by a steam vacuum system.

All the piping used for high-pressure steam together with the boiler feed and boiler blowoff is extra-heavy genuine wrought iron. All valves on the superheated steam lines are outside screw and yoke, rising stem pattern, the valves having cast-steel bodies with monel-metal seats, disks and trimmings. On all superheated-steam

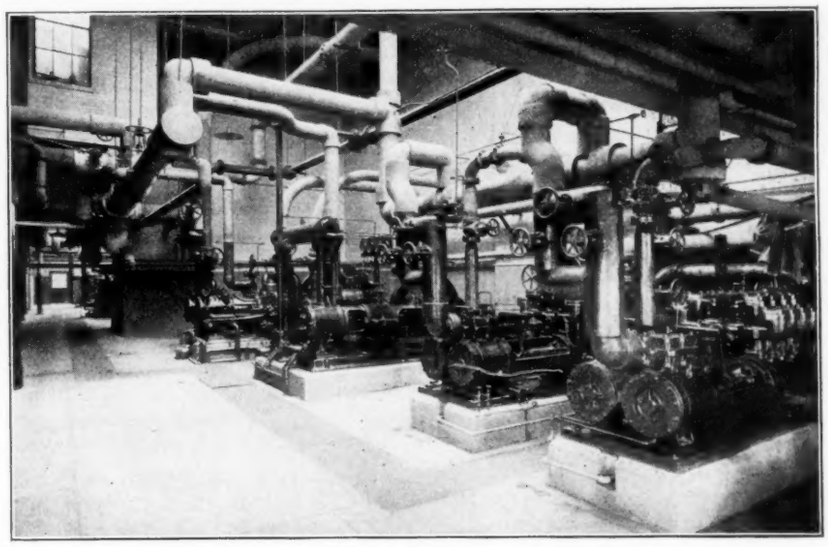


FIG. 9. PUMPS AND AIR COMPRESSORS

lines, the flanges are extra-heavy forged steel welded to the piping.

A steam-driven air compressor was transferred to the new plant and an additional cross-compound single-stage machine having a capacity of 835 cu.ft. of free air per minute at 50 lb. per sq.in. was installed. The high duty pumping engine was also transferred and a three-cylinder compound Corliss pumping engine was added to the equipment. The latter is designed for noncondensing service and has a capacity of 245 gal. per min. against a total water pressure of 800 lb. It was also possible to utilize a number of small pumps that had been in service.

TABLE 3. EIGHT-HOUR TEST WITH SAWDUST FUEL

Date of test	9/30/15
Type of boiler	B. & W. water-tube
Maker's rating, boiler horsepower	520
Square feet of grate surface	90
Square feet of heating surface	5,200
Kind of fuel used	Sawdust
Steam pressure, gage, av. lb.	176.3
Temperature of feed water, av. deg. F.	190
Percentage of moisture in fuel	7.57
Fuel per square foot of grate per hour, lb.	54.5
Water evaporated per pound of fuel as fired, lb.	4.33
Water evaporated per pound of dry fuel, lb.	4.69
Water per pound of fuel from and at 212 deg., lb.	5.09
Water per pound of dry fuel from and at 212 deg., lb.	5.50
Horsepower developed (actual)	723
Per cent. of rating	139.04
Temperature of superheated steam, av., deg. F.	560
Temperature of flue gases at top of third pass, deg. F.	544
Draft at furnace door, in. water	0.18
Draft at top of third pass, in. water	0.41
Draft at base of stack, in. water	1.25
CO_2 in flue gases at top of third pass, per cent.	10.8
Maximum CO_2 observed, per cent.	12.5
Minimum CO_2 observed, per cent.	8.8
Maximum CO observed	0
Minimum CO observed	0
B.t.u. per pound dry fuel (analysis)	8,230
Efficiency of boiler and furnace combined (based on dry fuel), per cent.	64.9

After the power plant had been designed and installed, a sudden change was made in the disposition of the work between some of the mills owned by the company. Formerly the lumber in the rough had been shipped direct to South Bend. A saving in freight rates, however, induced the company to trim the lumber to dimension sizes at its Southern mills at Truman, Ark., and Cairo, Ill. This greatly reduced the wood-fuel supply at South Bend, and the European War also had the effect of reducing the output and consequently the waste available for use as fuel. In 1912 the wood fuel averaged 120 tons per day, while at present it runs as low as 35 tons.

It had been the plan to store the excess of sawdust in the summer months when the demand for fuel is less and use the surplus to supplement the supply during the heating season. The reduced supply, however, scarcely meets the requirements of the 10-hr. working day in the summer months, having to be supplemented by coal at times. Coal is burned exclusively at night, for supplying steam for the dry-kilns, pumps and lighting. As the weather becomes colder more coal is required. As the extension furnaces were not designed for the burning of coal, and therein are not very efficient, and as it is impossible to get rating capacity out of the boilers when hand-firing Illinois or Indiana slack, it was decided, as an economical proposition, to change over the furnaces of two boilers and install automatic stokers. These will be ready for operation soon. It is intended to burn, on these stoker grates, sawdust and wood chips, and coal, either singly or combined in various proportions, according to the supply of wood fuel. For the present the stoker coal hoppers will be filled by hand, but an installation of overhead coal bins and the necessary conveyors is under way and will be completed shortly.

A railroad track runs along the boiler-room side of the power house. The conveying machinery consists of a hopper under the track, an apron conveyor into the power house, an elevator and flight conveyor over the bins. The bins are each of 50 tons' capacity. The coal is spouted from them into scales placed on the second firing floor, thence into the stoker hoppers.

As the volumes of wood chips and coal per pound are about six to one, to get the capacity out of the boilers the chips must be fed in correspondingly large quantities. This is made possible by means of a variable-speed transmission system. With straight coal fuel, the grate travel will be about 4 in. per min. with the gate 6 in. high, whereas when using wood chips the grate travel will be 12 in. per min. with the gate 12 in. high.

Two variable-speed gears are driven by the one engine transmitting the power to two separate eccentric shafts. By this flexible arrangement the two stokers can be driven at different speeds to suit the quality of the fuel. This is believed to be the only arrangement of its kind.

On account of burning wood fuel, it was considered best to install the stokers in an extension furnace on similar lines to the present ones. These two furnaces extend 11 ft. 3 in. beyond the front of the boilers. The ignition arch is 7 ft. 9 in. long inside, and the higher part of the arch is 6 ft. 3 in. long. The grates are 11 ft. wide and 11 ft. 4 in. long inside the brickwork. It is proposed to run a number of evaporation tests on these units as soon as practicable to determine the gains in efficiency by the change.

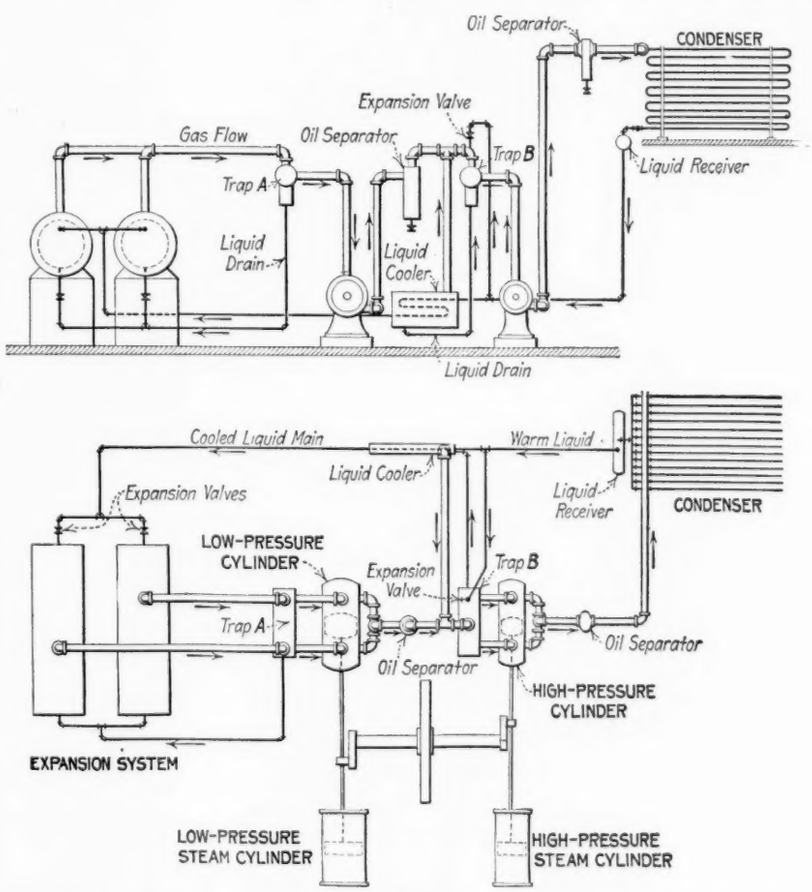
Table 2 shows the coal consumption for the last six years. The new plant was put into operation Jan. 1, 1915. During that year it is evident that the coal consumption was about 4,000 tons less than the previous average. With coal at $1.60 per ton, this represents a saving of $6,400. With the former supply of wood fuel available it has been estimated that the demand for coal would have been reduced to 7,000 tons per year, the difference between this and the former average approximating $18,000.

Table 3 is a copy of one of several tests conducted when burning sawdust. It will be seen that an evaporation from and at 212 deg. F., of 5.5 lb. of water per pound of dry fuel was obtained. The maximum CO_2 observed was 12.5 per cent. and the minimum 8.8 per cent. The B.t.u. per pound of dry fuel was by chemists's analysis 8,230. Based on dry fuel an over-all boiler and furnace efficiency of 64.9 per cent. was obtained. This may be compared to an average of 50 per cent. in the older plant. The stokers will make possible higher combustion rates.

D. I. Davis Low-Temperature Compression System

Obtaining low refrigerating temperatures by means of the simple compression system is uneconomical because of low volumetric efficiency and the disproportionate increase in power required as the suction pressure is lowered. Vapor from one pound of ammonia evaporated in the refrigerator at zero suction pressure occupies more than double the space of the vapor at 20 lb. pressure, so that the quantity of refrigeration duty produced for the actual displacement of the compressor is greatly reduced at the lower suction pressure. Vapor in a very rare state must be handled by the compressor. As the temperature of the refrigerator is low and the liquid ammonia must be reduced to the same temperature before it can do useful work, the evaporation of as much as 20 per cent. of the refrigerant to cool itself may be necessary. There is also a large increase in the temperature of the discharged vapor as the suction pressure is reduced. All these factors add to the cost of operating the compression system of producing refrigeration at low suction pressures and in the past have resulted, where suitable, in the installation of "booster" equipment taking its suction from the low back-pressure mains and discharging into the suction mains of the ordinary operation. This at best was a make-shift arrangement and eventually led to the development of a two-stage system of compression by D. I. Davis, of Chicago. Although this system is intended to operate on low-temperature brine, it is usable under many conditions where low temperatures are needed, obviating the necessity for two brine temperatures or a duplication of refrigerating machinery to meet the demand for freezing and various other temperatures in commercial cold storage.

As shown in the diagrams, the Davis low-temperature compression system consists of a two-stage compressor driven by a cross-compound steam engine with additional liquid coolers, traps, etc. The equipment is all standard, the economy being effected by the combination system. As will be evident from the illustrations, the equipment consists of brine coolers or other expansion system, a low-pressure vapor trap and equalizer, a low-pressure



DIAGRAMMATIC LAYOUT OF THE D. I. DAVIS LOW-TEMPERATURE COMPRESSION REFRIGERATION MACHINE

vapor cylinder an intermediate vapor trap and equalizer, a high-pressure vapor cylinder, liquid cooler, etc.

Beginning with the brine cooler, which may be of any form, or with rooms cooled by direct expansion coils, the vapor is conducted to a drum *A* interposed between the expansion side and the low-pressure cylinder. This drum, or trap, serves the purpose of trapping the liquid that may be entrained, so that it may be conducted to the coil supply as in a flooded system, and also serves as an equalizer to balance the vapor supply to either end of the low-pressure cylinder.

At the low temperature resulting from low back pressures, the ammonia vapor becomes so attenuated that it is necessary to handle a large volume per ton of refrigeration developed. To provide for this the low-pressure cylinder is made about double the volume of the high-pressure cylinder. In the former the vapor is compressed to a predetermined pressure and passed through an oil separator to the equalizer and trap *B*. From here it enters the high-pressure cylinder at a relatively high pressure of about 30 lb. and fully saturated, so that the volumetric efficiency of this cylinder should also be high. The condenser to which the vapor at high pressure then passes may be any of the various types commonly used.

The liquid ammonia used for a cooling medium must be reduced to a temperature equal to its evaporation point before it can become effective. Instead of doing this in the coolers, as is usual, the liquid is passed through a heat exchanger in which its temperature is lowered before it is introduced into the expansion system. A branch pipe from the main liquid line is connected to an expansion valve attached to trap *B*. A suction connection is carried from the heat exchanger, or liquid cooler, to the main leading from the low-pressure cylinder, so that the flow through it mingles with the vapor in the equalizer *B*, taking up the heat of compression from the low-pressure cylinder. The liquid cooler is operated flooded from the trap *B*.

As the vapor remaining in the clearance space between the cylinder head and the piston at the end of each stroke must expand to the suction pressure before the cylinder begins to fill through the suction valves, the reduction in the range of pressure for each cylinder will result in higher volumetric efficiency. In the ordinary compressor each cylinder has a condition of, say, 0 to 5 lb. suction pressure and 180 lb. condensing pressure, while in the system under discussion the range for each cylinder is considerably less. Cooling the liquid ammonia decreases the amount of vapor that must be handled by the low-pressure cylinder, and compressing in two stages reduces the heat of compression.

The vapor leaving the low-pressure cylinder is cooled to the temperature of saturated vapor at the intermediate pressure, so that the temperature of the high-pressure discharge will be within the safe limits for ammonia. In the cooling of this liquid the vapor used intermingles with the gas from the low-pressure cylinder to the high-pressure cylinder, equalizing the heat of compression in the low-pressure cylinder. In the low-temperature refrigerator the range through which the liquid ammonia must be cooled will be comparatively small, so that the evaporation of only a small part of the refrigerant will be required for its cooling.

With the two-stage compressor and other improvements mentioned, the power requirements are claimed to be only about 70 per cent. of the normal power for an ordinary compression plant operating under equivalent conditions. With a high-pressure compound steam engine developing an indicated horsepower on 11 lb. of steam, it has been estimated that the D. I. Davis system will produce a ton of refrigeration on 20 lb. of steam, which may be compared to 30 to 40 lb. of steam normally required on low-temperature work. There is the added advantage of simplicity over the duplicate systems mentioned in the first part of the article.

Several large refrigerating-machine manufacturers have made arrangements to manufacture the D. I. Davis system and are now licensees for the United States and foreign countries. It is likely that the industries will more and more require low temperatures for the manufacture of many products.

How Should Gas Be Measured?

By R. L. Spencer

One of the problems that confronts every engineer who attempts the thorough test of a gas producer or producer-gas engine is how to measure the cubic feet of gas produced or used. There is no more important item in the test and probably none that will call for more ingenuity on the part of the engineer. The methods employed by the author to obtain the flow of gas may be divided into four groups, according to the character of the operation, as follows:

1. Gasometers, which measure the gas volumetrically and indicate or record the total volume that has passed through the meter.

2. Pitot tubes and venturi meters, which indicate the velocity of the gas by measuring the velocity head.

3. By metallurgical calculation from the analyses of gas, coal and refuse, equating the total carbon burned to the total carbon in the gas.

4. By using the whole scrubber as a cooling coil and equating the heat absorbed by the scrubber water to the heat given up by the gas in passing through the scrubber.

Of the four processes outlined the gasometer method is by far the simplest and most reliable for small plants. The accuracy of the meter should be tried before and after the test and its true correction factor determined. In plants in operation it is often impractical and too expensive to dismantle the plant sufficiently to install a gasometer. In large plants a gasometer of a size capable of measuring the gas accurately is often impossible to obtain or is of prohibitive cost.

The measurement by pitot tube or venturi meter is a convenient method of approximating the flow of gas. The apparatus is simple and easy to install and operate, and the calculations are comparatively simple. It may be equipped to produce a record of the variation in the gas flow from time to time. In many cases, however, this method is so inaccurate as to be useless. An examination of the formulas of both the pitot tube and venturi meter will show that the deflection of the liquid in the

U-tube is proportional to the square of the velocity. Where the flow is at all fluctuating, as is nearly always the case in the gas main leading to the engine, the liquid in the manometer will be deflected an amount proportional to the average of the squares of the various velocities. If the deflection is then used as representing the deflection due to the average velocity, the results obtained are likely to be decidedly inaccurate. Further, every tube has its individual coefficient of discharge the value of which depends on the size and shape of the orifices; gas, which is dirty, will often coat or clog the orifices so as to seriously affect the coefficient of discharge and the smaller the orifice the greater, of course, the effect will be. The writer calls to mind an instance where four pitot tubes of standard make were carefully installed in a 16-ft. length of 6-in. pipe leading to a four-cylinder producer-gas engine. The total as indicated by each of these tubes was excessive, in some cases exceeding the total piston displacement, and different in each instance. In using either a pitot tube or venturi meter, the gas must be analyzed in order that its density may be calculated.

Calculations from the analyses of gas, coal and refuse are based on the assumption that the weight of the element carbon in the gas is equal to the weight of the carbon in the coal fired minus the weight of unburned carbon in the refuse, and the data necessary are the total weight of dry coal fired per unit time, the total dry refuse extracted per unit time, an ultimate analysis of dry coal by weight, the percentage of carbon in the dry refuse and an analysis of the gas by volume. The method is best illustrated by following through a specific problem, as follows:

Analysis of gas by volume:	Per Cent.
CO_2, carbon dioxide	0.70
CO, carbon monoxide	25.22
O, oxygen	1.69
H, hydrogen	2.60
CH_4, Marsh gas	0.47
N, nitrogen, by difference	69.32
	100.00

Ultimate analysis of dry coal by weight:	Per Cent.
C, carbon	77.77
H, hydrogen	2.60
O, oxygen	5.41
N, nitrogen	0.79
S, sulphur	0.61
Ash	12.88
	100.00

Moisture in coal as fired, per cent	2.66
Dry coal fired per hour, lb.	211.8
Total ash and refuse per hour, lb.	44.3
Unburned carbon (C) in refuse, by weight, per cent	42.03

The carbon in each ingredient of the gas per cubic foot of the gas is equal to the cubic feet of the ingredient in each cubic foot of the gas times the pounds of carbon in each cubic foot of the ingredient, thus:

Lb. carbon in the CO_2 in each cu.ft. gas = 0.007 × 0.0317 = 0.0002219 lb.
Lb. carbon in the CO in each cu.ft. gas = 0.2522 × 0.0317 = 0.0079947 lb.
Lb. carbon in the CH_4 in each cu.ft. gas = 0.0047 × 0.0318 = 0.0001499 lb.

Total carbon in each cu.ft. gas at 60 deg. F. and 30 in. mercury = 0.0083665 lb

Carbon fired in coal per hour = 211.8 × 0.7777 = 164.72 lb.
Unburned carbon in refuse per hour = 44.3 × 0.4203 = 18.62 lb.

Total carbon consumed per hour = 164.72 — 18.62 = 146.10 lb.
Equivalent cu.ft. of gas per hour at 60 deg. and 30 in. mercury = 146.10 ÷ 0.0083665 = 17,463 cu.ft.

This method of calculating the flow of gas requires very little apparatus and is readily applicable to any producer-gas plant, but the test must be of long enough duration so that the error in assuming that the coal fired equals the coal consumed is negligible. Great care must be exercised in sampling the coal and refuse to obtain an average sample. An ultimate analysis of the coal is, of course, necessary. This should be undertaken only by competent chemists who are equipped with the necessary apparatus and are thoroughly experienced in making similar analyses. Most engineers would best send a sample of the coal and refuse to commercial chemists for analysis.

Calculation by using the whole scrubber as a cooling coil is based on the assumption that the heat given up by the gas in passing through the scrubber is equal to the heat taken up by the scrubber water. The necessary data are an analysis of the gas by volume, the weight or volume of scrubber water in unit time, the temperature of the gas on entering and leaving the scrubber, and the temperature of the water on entering and leaving the scrubber. The calculation may be carried on using either weight or volume of gas per unit time as the basis. Let

G = Quantity of gas flowing in unit time;
W = Lb. of scrubber water used in unit time;
C_G = Specific heat of gas;
t_1 = Temperature of gas entering the scrubber;
t_2 = Temperature of gas leaving the scrubber;
t_3 = Temperature of water entering the scrubber;
t_4 = Temperature of water leaving the scrubber;

Then

$$W(t_4 - t_3) = GC_G(t_1 - t_2), \text{ or } G = \frac{W}{C_G} \times \frac{t_4 - t_3}{t_1 - t_2}$$

To illustrate the calculations necessary with this method assume the analysis of gas by volume already given and in addition the following:

Temperature of gas entering scrubber, t_1 = 313.2 deg. F.
Temperature of gas leaving scrubber, t_2 = 81.4 deg. F.
Temperature of water entering scrubber, t_3 = 50.7 deg. F.
Temperature of water leaving scrubber, t_4 = 107.6 deg. F.
Total cu.ft. of water to scrubber per hr. = 22.6.

PROPERTIES OF SOME OF THE COMMON COMMERCIAL CASES; CALCULATED FOR 60 DEGREES F. AND 30 INCHES OF MERCURY

Molecular Formula*	Atomic Weight	Exact Molecular Weight	Density (Air = 1)	Specific Gravity, Lb. per Cu.Ft.	Specific Vol., Cu.Ft. per Lb.	Heat Value Higher Per Lb.	Heat Value Higher Per Cu.Ft.	Heat Value Lower Per Lb.	Carbon in Gas, Lb. Per Cu.Ft. of Gas	Gas, Lb. Per Lb. of Gas	Oxygen Required to Burn Lb. per Lb. of Gas	Oxygen Required to Burn Cu.Ft. per Lb. of Gas	Air-Required to Burn Lb. per Lb. of Gas	Air-Required to Burn Cu.Ft. per Lb. of Gas	Combustion Equation	Lb. of Products of Combustion per Lb. of Gas (With Air) CO_2	H_2O	N	Specific Heat at Constant Volume Per Lb.	Per Cu.Ft.
H_2	1.008	2.015	0.0695	0.005335	188.5	61,950	329.9	52,500	.....	.....	8.0	0.5	34.78	2.40	$2H_2 + O_2 = 2H_2O$	.....	9.0	26.78	3.4	0.01814
C†	12.00	12.00	0.820†	0.006325	15.81	14,540	920.0	14,540	0.006325	1.0	2.6667	2.0	11.52	.....	$C_2 + 2O_2 = 2CO_2$	3.66	....	8.92	.....	.....
C_2†	12.00	12.00	0.820†	0.006325	15.81	14,540	920.0	14,540	0.006325	1.0	1.3333	1.0	5.76	.....	$C_2 + O_2 = 2CO$	.....	....	4.46	.....	.....
CO	.....	28.00	0.967	0.074029	13.53	4,380	317.8	4,380	0.0317	0.4286	0.5714	0.5	2.48	2.38	$2CO + O_2 = 2CO_2$	1.57	....	1.91	0.247	0.01827
C_2H_2	.....	26.03	0.898	0.0686	14.57	21,430	1497.0	20,670	0.0633	0.9231	3.0769	2.5	13.35	11.99	$2C_2H_2 + 5O_2 = 4CO_2 + 2H_2O$	3.38	0.69	10.28	.....	.....
CH_4	.....	16.03	0.553	0.042434	23.67	23,840	1002.1	21,380	0.0318	0.7500	4.0000	2.0	17.30	9.56	$CH_4 + 2O_2 = CO_2 + 2H_2O$	2.74	2.25	13.31	0.592	0.0251
C_2H_4	.....	28.04	0.938	0.074113	13.53	21,430	1595.0	20,020	0.0635	0.8571	3.4286	3.0	14.95	14.58	$C_2H_4 + 3O_2 = 2CO_2 + 2H_2O$	3.14	1.29	11.52	0.37	0.0274
H_2O	.....	18.02	0.622	0.0475	21.08	.....	.....	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	0.48	0.0228
N_2	14.01	28.02	0.970‡	0.074082	13.49‡	.....	.....	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	0.245	0.01814
O_2	16.00	32.00	1.105	0.084608	11.84	.....	.....	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	0.217	0.01835
CO_2	.....	44.00	1.529	0.116333	8.57	.....	.....	.....	0.0317	0.2727	.....	...	.....	.....	.....	.....	.....	.....	0.215	0.0250
Air	.....	.....	1.000	0.0764	13.09	.....	.....	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	0.237	0.01812

* H_2 = hydrogen, C_2 = carbon, CO = carbon monoxide, C_2H_2 = acetylene, CH_4 = methane, C_2H_4 = ethylene, H_2O = water vapor, N_2 = nitrogen, O_2 = oxygen, CO_2 = carbon dioxide. † Considered as a gas. ‡ For "nitrogen" of the atmosphere.

Then the heat necessary to raise the amount of each ingredient in a cubic foot of the gas one deg. F. is equal to the volume of the ingredient in a cubic foot of the gas multiplied by the specific heat of the ingredient in B.t.u. per cubic foot per degree F., thus:

Heat to raise CO_2 in 1 cu.ft. gas 1 deg. F. = 0.007 × 0.025 = 0.000175.

Heat to raise CO in 1 cu.ft. gas 1 deg. F. = 0.2522 × 0.01827 = 0.004608.

Heat to raise O in 1 cu.ft. gas 1 deg. F. = 0.0169 × 0.01835 = 0.000310.

Heat to raise H in 1 cu.ft. gas 1 deg. F. = 0.026 × 0.01814 = 0.000472.

Heat to raise CH_4 in 1 cu.ft. gas 1 deg. F. = 0.0047 × 0.0251 = 0.000118.

Heat to raise N in 1 cu.ft. gas 1 deg. F. = 0.6932 × 0.01814 = 0.012575.

Specific heat of 1 cu.ft. of gas at 60 deg. F. and 30 in. mercury, C_G = 0.019832.

Weight of scrubber water per hour, W = *volume* × *density* = 22.6 × 62.41 = 1,410.47 *lb.*

Equivalent cubic feet of gas at 60 deg. and 30 in.,

$$G = \frac{W}{C_G} \times \frac{t_4 - t_3}{t_1 - t_2} = \frac{1{,}410.47}{0.019832} \times \frac{107.6 - 50.7}{313.2 - 81.4}$$

$$= 17{,}459 \; cu.ft.$$

The advantages of this method are: The small amount of apparatus required and the ease of its installation; no analysis of coal is required; the method is as accurate for a reasonably short test as for a long one, and for a long test the variation in the flow from time to time may be calculated. By comparing the calculated specific heats of a number of common producer gases it will be found that the specific heat varies relatively little with the composition of the gas, therefore a small error made in the gas analysis will make relatively a very small error in the calculated flow of gas. Great care must be taken to obtain the correct mean temperature of the gas and water. The thermometer wells should extend well across the pipe, and the thermometers should read to tenths of degrees and be corrected for emergent stem. There are some errors introduced when this method is used, due to radiation from the scrubber, absorption of some of the gas by the scrubber water and neglect of the water vapor carried along with the gas. These errors are small enough not to affect the practical value of the results obtained.

U. F. C. Boiler Efficiency System

The increasing cost of anthracite fuels for boiler use in cities where the smoke ordinance is enforced has brought out a number of smoke prevention systems to permit of burning bituminous coal. Many utilize steam jets that furnish a supply of air either to the furnace or to the combustion chamber of the boiler. One such is the U. F. C. System, installed by the United Furnace Corporation, Philadelphia. Two features are prominent in this system—the circulating pipes and the distribution of steam and air to the combustion chamber. Both can be installed on a return-tubular boiler without material alteration.

To allow putting on the circulating pipe one tube next to the lower portion of the shell must be removed. A nipple is welded into the tube hole, and the pipe connection is carried to the rear end of the grate bars, where a return-bend fitting is used. The end attached to the boiler connection is 4 in., and the other is 6 in., into which a 6-in. cross-pipe is fitted. From the other end of the cross-pipe a connection drops to the bottom of the combustion chamber, and running diagonally across it, turns up and connects with the rear tube head of the boiler through a nipple welded in the tube hole in the tube sheet. For convenience in cleaning, a tee fitting is placed on the nipple connection at each end of the boiler, the outer opening being plugged. The cross-pipe at the end of the grates is 6 in. diameter and the rest of the piping is 4 in. All piping and fittings are of steel, and to reduce friction in the passage of water through them, the latter are made with as long-radius bends as possible. As about three-quarters of the cross-pipe and all the forward portion of the front 4-in. connection are exposed to the intense furnace heat, the circulation of the water is very rapid. Above the cross-pipe of the circulating system is a saddle on which rests an air- and steam-jet header so placed that the openings of the air jets face toward the rear of the combustion chamber. This header has a cross-sectional area equal to that of a 3½-in. pipe, or 9.62 sq.in. It is protected from the furnace heat by a firebrick cap, as shown, provision being made for the free delivery of air to the combustion chamber. The outlet nozzles are a part of the casting, the interior surface being made with easy curves to avoid friction and cross-currents. One end of

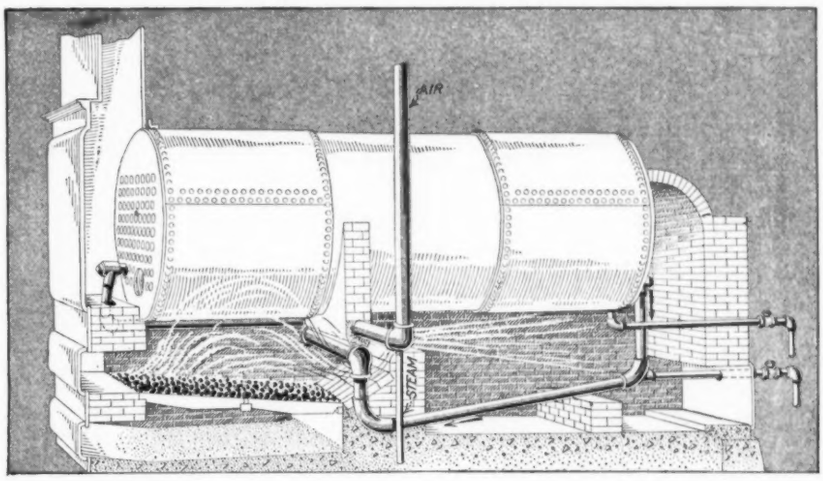


FIG. 1. APPLICATION OF THE SYSTEM TO A RETURN-TUBULAR BOILER

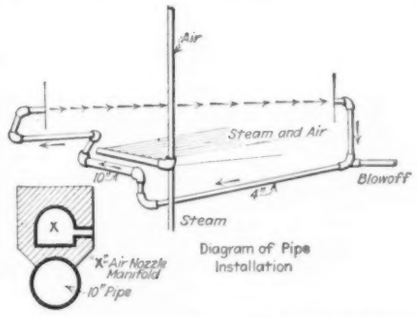


FIG. 2. DIAGRAMMATIC VIEW OF PIPING

the header is closed; the other is fitted with a special design of ell connection, and an air-inlet pipe extends vertically to about level with the top of the boiler setting. At the bottom of the ell fitting is a ⅜-in. steam connection terminating in a nozzle inside of the ell. When steam is turned on this nozzle, air is drawn in at the top of the air pipe connecting with the nozzle header and the steam and air are distributed to the gases in the combustion chamber, and these produce an improved state of combustion. Fig. 1 shows the system as applied to a return-tubular boiler. Fig. 2 is a diagrammatic view of the piping.

It will be seen that above the cross-pipe and the steam and air header a baffle wall is constructed against the boiler shell and that the position of the bridge-wall is back of where it is found in the ordinary furnace setting. This arrangement prevents the flow of furnace gases in a straight path to the rear of the boiler and forces the flames up against the boiler shell at a point above the grates. They then sweep under the cross-pipe of the circulating system and, striking the bridge-wall, are deflected toward the boiler shell in the combustion chamber. It is here that the air and steam from the air pipe and header combine with the gases and produce a more nearly perfect combustion than is generally possible with the ordinary boiler and furnace construction. This system has already been placed in a number of plants. One visited is the Charles Cooper & Co.'s plant, Newark, N. J., where it is giving satisfactory results, a material saving having been made in fuel consumption with a corresponding increase in water evaporated per pound of coal fired.

The Moore Steam Turbine

The ever increasing use of the steam turbine is again emphasized by the entrance into the field of another American manufacturer, the Moore Steam Turbine Corporation, of Wellsville, N. Y. Fig. 1 shows an exterior view of the Moore steam turbine connected to a centrifugal pump. The single-stage machine consists of a single-velocity stage made up of a set of diverging expanding nozzles and a wheel carrying two rows of moving blades, with a set of stationary reversing vanes following the first row of moving blades. The builders

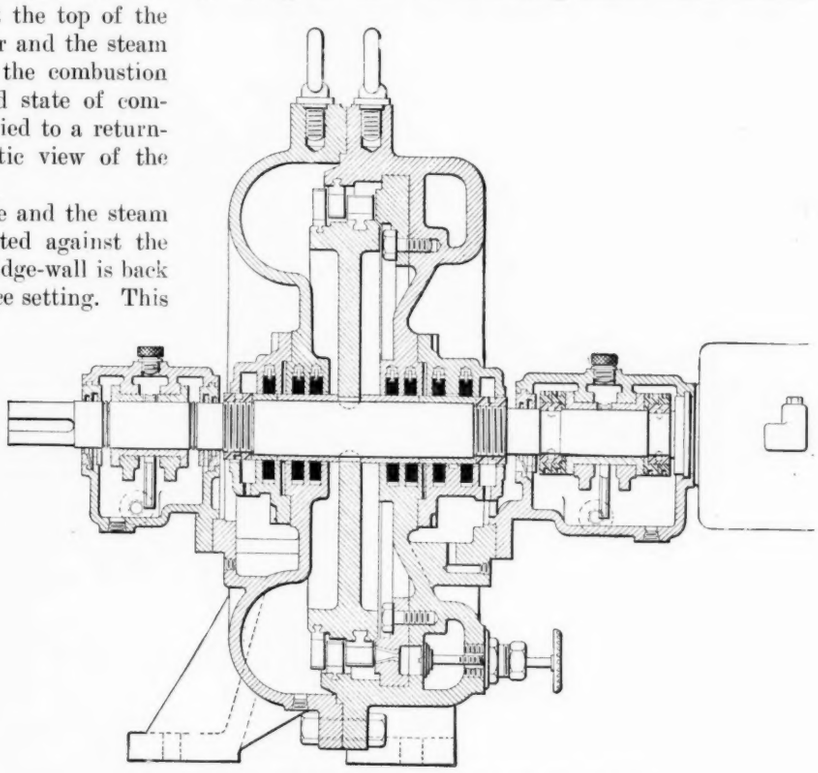


FIG. 2. SECTION SINGLE-STAGE TURBINE

will limit the speeds of the larger machines to 3,600 r.p.m. and of the smaller ones to 5,000 r.p.m. as a maximum and obtain the required steam consumption by multi-staging if necessary. This is done to minimize the rotation stresses. A section of one of these single-stage turbines is shown in Fig. 2.

The multi-stage turbine consists of the same single-velocity stage used in the single-stage machine, followed by two or more single-pressure stages. Each of these stages consists of a set of nozzles and a wheel, as shown in the sectional view, Fig. 3.

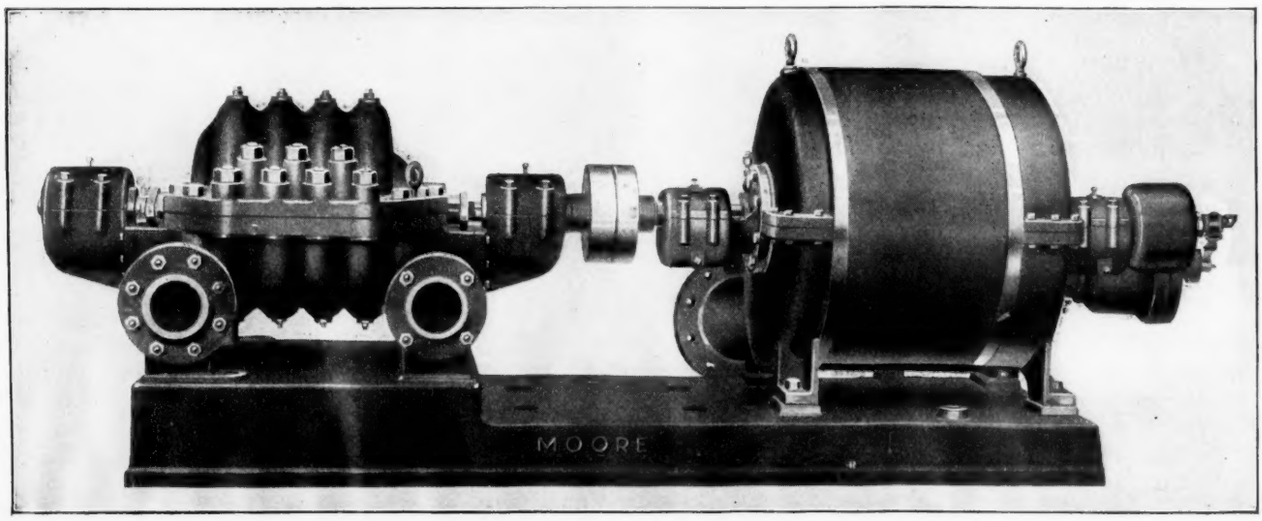


FIG. 1. MOORE TURBINE CONNECTED TO BOILER FEED PUMP

In both the single-stage and the multi-stage turbines of all sizes, the casings are divided both vertically and horizontally. This allows of lifting the casing without breaking the steam or exhaust connections and is unusual in turbine design. The diaphragms are halved and are

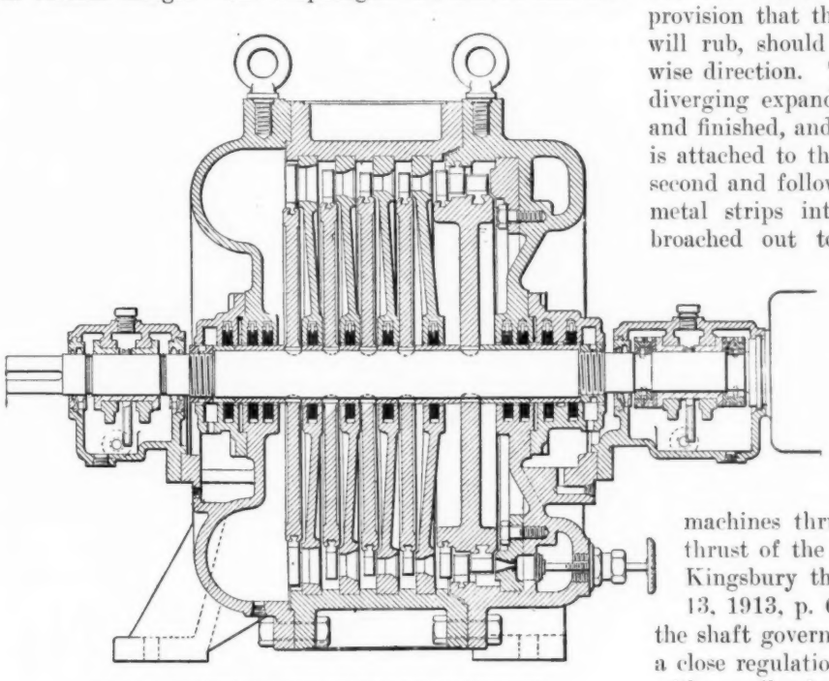
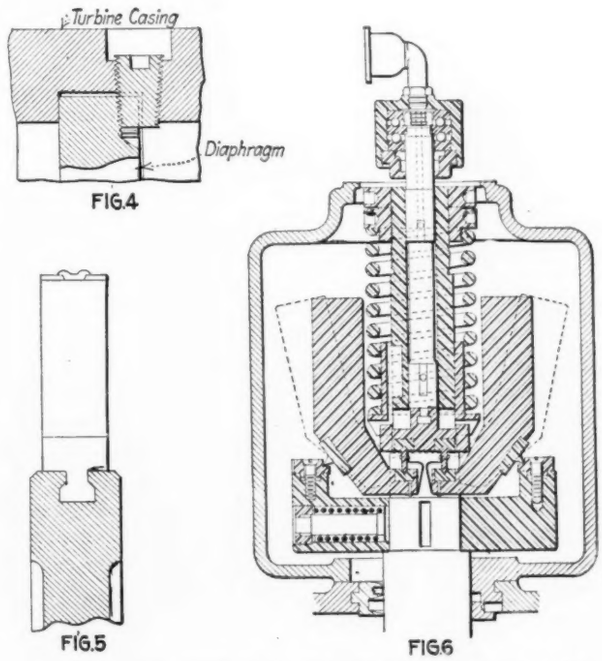


FIG. 3. SECTION MULTI-STAGE MACHINE

held in the casings by a set of special tapered screw plugs inserted in the vertical joints, while the diaphragm and casing are held in a fixture. This construction is



FIGS. 4 TO 6. THE MOORE STEAM TURBINE PARTS

Fig. 4—Screwed diaphragm plugs. Fig. 5—Section, showing blade fastening. Fig. 6—Section of the governor

unusual, as dowel pins are generally used instead of screwed plugs. Fig. 4 shows how the screw plug is used.

The wheels and shaft are of steel, and the first-stage wheel is a built-up or solid-forged construction. The wheels of the single-pressure stage are machined from solid steel plates. The buckets are of drawn steel and dovetailed into the periphery of the wheel, as shown in Fig. 5. The clearance over the bucket is about ½ in., and the endwise clearance is liberal, with the further provision that the side of the wheel and not the bucket will rub, should the rotor become displaced in an endwise direction. The nozzles in the first stage are of the diverging expanding type and are made of bronze, cast and finished, and then recast into a cast-iron ring, which is attached to the steam-end casing. The nozzles of the second and following stages are formed by casting sheet-metal strips into the diaphragms. These nozzles are broached out to a gage. Reversing vanes are used between the two rows of moving buckets from the first-stage wheel. These are set in somewhat the same way as the buckets are set into the periphery of the wheel. A nozzle section is shown in Fig. 7. The bearings are provided with oiling rings or forced lubrication, or both, depending upon the size of the turbine. In the smaller machines thrust collars are provided to take up the thrust of the rotor; while in the larger machines the Kingsbury thrust bearing (described in *Power*, May 13, 1913, p. 667) is used. Fig. 6 shows a section of the shaft governor. For the larger machines and where a close regulation is desired, the Jans governor, together with an oil relay governor, is used.

Where reduction gears are employed, they are of the double-helical or herringbone type, with a pressure angle of 20 deg. and a helix angle of 30 deg. The gears, made of a solid forging, are of built-up construction consisting of steel rings shrunk on cast-iron centers; the pinions are solid-forged from chrome-nickel or chrome-vanadium steel. The larger-sized machines are of course provided with oil cooling devices.

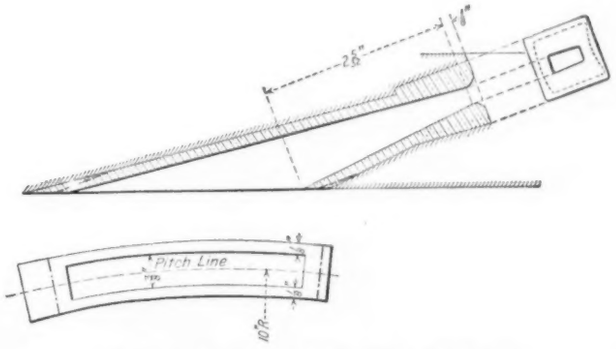


FIG. 7. SECTION OF STEAM NOZZLE

Formulas Relating to the Flow of Steam in Pipes have all been based upon a few experiments limited to pipes of small diameter, hence their application to larger pipes or to conditions other than those under which they were deduced, is apt to lead to considerable error. In small pipes extreme accuracy in determining the proper sizes is not necessary, and it is probably better to install too large a pipe than one too small; but in larger sizes for high pressure the cost of piping increases rapidly with the size and the first-cost item is important. The problem therefore is: Given the desired pressure at the throttle, the maximum weight of steam per unit of time and the length of pipe, determine the minimum diameter of pipe to conduct the steam without undue drop in pressure.

Visits of Inspector Brown--XXII

By J. E. Terman

SYNOPSIS—Seeing that Brown was interested in diagraming formulas, the Chief shows him how a formula can represent a straight line when the line would not pass through the intersection of the vertical and horizontal axes.

"The last time we were discussing the subject of diagraming formulas, Brown, I promised to show you about a formula that would represent a straight line, but where the line would not pass through the intersection of the x and y axes. You remember that the formula for a straight line $y = ax$ gave the points along the hypotenuse of a right-angled triangle the base of which was the axis of x; the y axis passed through the left-hand end of the triangle so that the intersection of the axes was located at this end of the base line, like this," producing Fig. 1.

"There is no reason why the axis of x may not be lowered or raised above the base line of the triangle; for example, if the x axis should be lowered, it would appear like this," showing Fig. 2, "the axis of x, of course, being parallel with the base BC of the triangle. The point A on the hypotenuse of the triangle would be represented by the same value of x in this case (Fig. 1) as before, but the value of y (Fig. 2) would be increased by the distance DC, which is the same as OB, and the value of y for any point on the line BA (Fig. 2) would be increased by OB, over the corresponding value in the case of Fig. 2. Therefore it is only necessary to add the constant value OB to each value of y in the formula representing OA (Fig. 1), to make the formula represent the value of y in case of Fig. 2. We will call this constant value of OB, b, and the formula $y = ax$ for the line OA here (Fig. 1) will become $y = ax + b$ for the line BA (Fig. 2).

"If the axis of x had been raised instead of lowered, here is the way the arrangement would have appeared," showing Fig. 3, "and it is readily seen that, in this case as before, the values of x are not changed and that the values of y are reduced by the amount OB, so that the formula representing this line BA (Fig. 3) would be $y = ax - b$. Therefore the equation $y = ax \pm b$ will represent a straight line, and this equation is the general equation for a straight line, the double sign $\pm$ indicating that the constant b may be either added to or subtracted from the right-hand side of the equation.

"You will see, Brown, that a line represented by $y = ax + b$ cuts the axis of y at a point b above the axis of x, and a line represented by $y = ax - b$ cuts the axis of x at a point $\frac{b}{a}$, to the right of the axis of y, or a distance b below the intersection of the axes of x and y. These results are obtained, first by giving x a value of zero in equation $y = ax + b$, which of course gives y a value of b, and in the second instance by giving y a value of zero in the equation $y = ax - b$, in which case x would equal $\frac{b}{a}$; or by giving x a value of zero in this equation when $y = -b$, as I stated, the minus sign indicating that the measurement was to be made below the axis of x.

"Now, Brown, you should understand that $x = ay \pm b$ would also represent a straight line, and such a line would have the same relation to the axis of y as $y = ax \pm b$ did to the axis of x. The first step to be taken when you have a formula to diagram is to see if it cannot be changed into the form of $y = ax$ or $y = ax \pm b$ without altering its value, and if this transformation is possible, you will know that straight lines may be used and that it will be necessary to obtain only two points on any line in order to draw it, and such a line will, of course, give all the values for the formula which it represents. There are many ways that may be used in order to get different formulas into the form of $y = ax \pm b$ or $y = ax$, and this is the real study in diagraming, for as I told you when we started on this subject, we will only concern ourselves with formulas represented by straight lines."

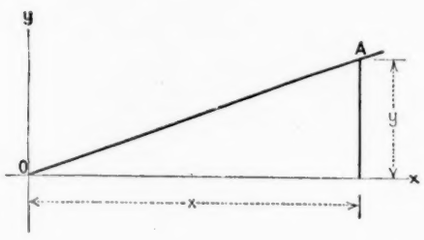


FIG. 1. AXIS X AT BASE LINE

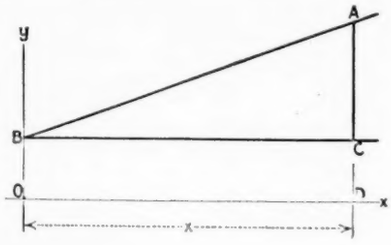


FIG. 2. AXIS X LOWERED

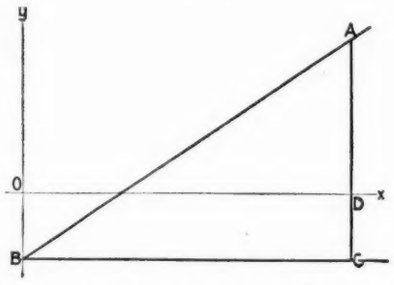


FIG. 3. AXIS X RAISED

"Well, Chief, how about rearranging this formula in the code for stay-bolt spacing, so that it may represent a straight line. It looks to me as if we would have to take it to Johnson's distillery in order to rectify it."

"You will have your little joke, Brown, but later on I believe we can juggle that formula into the form representing a straight line without the aid of spirits; but for the present I think if we use some other problem to demonstrate the practicability of diagraming formulas, it will be better for your understanding of the problem. For example, Brown, you and all the rest of the inspectors in this office are interested in the bursting pressures of solid cylinders. Jones and all the rest of the bunch have some sort of a table giving this information, for multiplying the bursting pressure of a solid cylinder by the efficiency of the joint and dividing this product by the factor of safety will give the working pressure. Don't you figure the strength of shells in that way, Brown?"

"Well, not always, Chief, because the table of bursting pressures that I have was copied from the one that Jones had and it is not complete enough for general use."

"I am glad that I happened to hit on this problem then, Brown, for there is certainly no reason why your information on this subject should lack completeness; for if the required results are derived from a diagram, more values simply mean more lines or extending the diagram. We will first write the formula for the bursting pressure of a solid cylinder. Of course I realize that you understand how to write this formula, but I will explain how the formula is derived so that you will be able to properly reëxplain it to some of your engineer friends.

"Now, here is a cylinder with a radius of r inches and a thickness of t inches," producing Fig. 4, "and by taking a strip 1 in. lengthways of the cylinder, it is evident that the bursting pressure in pounds per square inch, which we will designate by BP, times r, should be equal to the ultimate strength of a section of plate 1 in. long and of t inches thickness. These facts expressed in a formula would be written, $BP \times r = 1 \times t \times TS$, where TS is the tensile strength of the plate in pounds per square inch. Transposing the r and removing the one, since it has no significance in this formula, the formula becomes, $BP = \frac{TS \times t}{r}$ (1)."

"Well, Chief, I did know that the formula for the bursting pressure of a cylinder was as you have written it, but if someone had explained to me how it was derived by means of a sketch like that when I was trying to understand the subject, it would have helped me tremendously. However, I don't see how that formula," indicating formula (1), "for bursting pressures is to be a straight line."

"Well, Brown, if you have no objection to the use of a number of lines to represent the various values of r that you will be interested in and you are willing to make a separate diagram for each of the tensile strengths that you

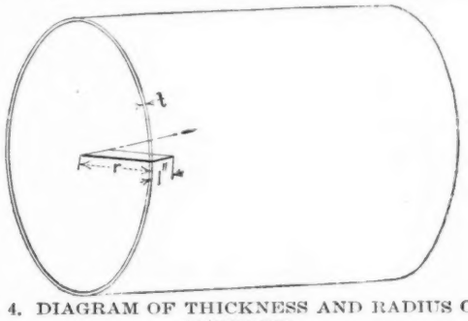


FIG. 4. DIAGRAM OF THICKNESS AND RADIUS OF A CYLINDER

will require considered, I am sure that the formula we have written will represent a straight line, for under the conditions I have named, it may be put in the form of $y = ax$. By assigning a fixed value for TS as well as for r, the resulting fraction will be the coefficient of the variable t, which corresponds to x in the formula of a straight line, and the variable representing bursting pressures will correspond to y."

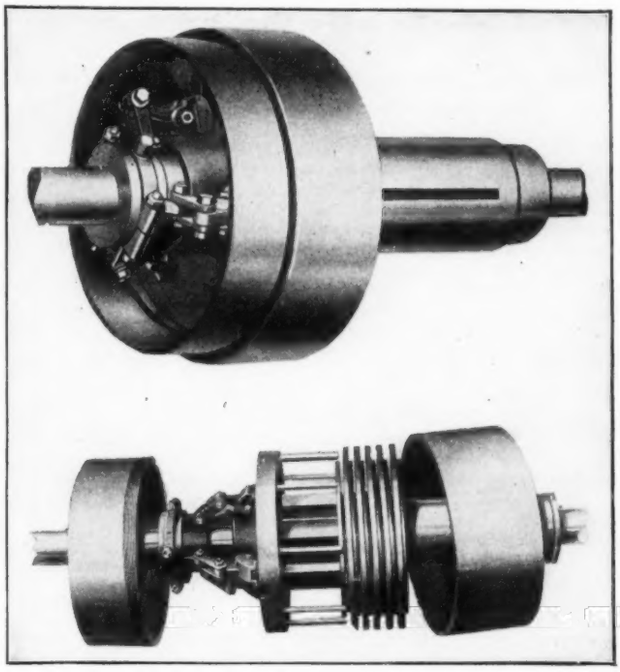
"Gee! That is easy, Chief. I can see how a diagram of that formula will be very simple to make."

"Well, Brown, you can have some time to consider that statement, and we will see the next time we get at it if you can draw such a diagram."

Forced Draft Aboard Ship—According to James Howden in a recent paper, reviewing the subject, "The honor of first using a blowing fan to accelerate combustion in a steamboat belongs to Edward A. Stevens, of Bordentown, N. J., who in 1827 in the 'North American' fitted boilers with closed ashpits into which the air was forced by a fan."

High-Speed Friction Clutch

The clutch here shown was especially designed for high speeds. It is of the metal-to-metal type, having bronze disks alternating with cast iron. The disks are lubricated,



HIGH-SPEED FRICTION CLUTCH

but do not run in an oil bath. They are fully inclosed, and all important parts are machined all over, so that the clutch is balanced. Engaging mechanism is such that there is no tendency to grab or drag when the clutch is released.

The clutch is made in loose-pulley and cutoff coupling types. It is available in sizes from 5 to 25 in. in diameter of bronze disks. Each size has from one to six disks, according to the capacity desired. The smallest size can be run up to 3,000 r.p.m., and the largest size up to 750 r.p.m. Powers transmitted are up to 630 hp. In sizes from 5 to 13 in. the clutches can be fitted directly on an extended hub of the pulley, gear or other member.

These clutches are intended for use with alternating-current motors when required to start under load, also for group drives to high-speed machinery and individual drives to woodworking and other heavy high-speed machines. They are made by the Moore & White Co., Philadelphia, Penn.

Cost of Electricity

Massachusetts was one of the first states to have a public-service commission, but does not enjoy the lowest rates for electrical service, as the following correspondence appearing in the Boston *Advertiser* would indicate:

I see that the company which supplies electricity to the people who live in Brooklyn has just been ordered by the New York Public Service Commission to reduce the price of current for household uses to 8c. per kilowatt-hour.

I notice, too, that in Cleveland and Toronto, publicly owned lighting plants, both reported to be operated at a clear profit, are selling domestic current at 3c. per kilowatt. The Toronto plant gets its current from Niagara, but the Cleveland plant makes it from coal.

In both Cleveland and Toronto the use of electricity in the home is much greater than it is in Boston. My last bill from the local electric company explains why. For 41 kw. I had to pay $4.10. In Cleveland or Toronto the same amount of electrical current would have cost only $1.23. Here is a differential against the consumer of $2.87.

What I should like to know is whether it costs more than three times as much to make and distribute electric current in Boston as it costs in Cleveland; and if so, why? L. S. R.

The inquiry of L. S. R. touches a very delicate question, to wit: How much profit may public-service corporations charge their consumers?

The cost per kilowatt-hour on the switchboards of our Eastern power plants is approximately 5 mills. This is the power-house cost. The interest and depreciation, as well as the line loss for the distributing system, might run this up to 7½ mills, and the overhead charges for legitimate office expense might increase this to one cent. The water-power companies sell power at this rate, for mill purposes. The larger steam plants also have about this same rate, as contracts are reported at 1 to 1½c. per kw.-hr.

The central stations claim that the expense of distributing, reading meters, billing, collecting, etc., increases their cost so much that they are forced to charge at least 10c. per kw.-hr. and that all they want is a "fair return on their capital stock." As a matter of fact, they are enormously overcapitalized and are taking exorbitant profits which they find difficulty in hiding. The erection of magnificent office buildings, the payment of big salaries, the employment of large staffs, the accumulation of surplus and reserve, and the high market value of their stocks, all attest this. There is no reason why the public-service corporations of New England should not reduce their rates to 5c. per kw.-hr. to small consumers and still make a handsome profit on their actual investment. It is true that coal is higher in New England than in any other part of the country, but the cost of 1,000 lb. of steam is not very different, for a cheaper coal has less evaporative power. Wages do not vary greatly in northern localities, and the water-power companies have, due to our munificent Government, a free source of power which should benefit the public, but which does not under the present arrangement. The benefit is taken by the promoters and stock jobbers who are handling these companies.

Several things could be done. Legislation might be enacted (if public protest was strong enough to offset the lobbies) which would cut down the capitalization of these companies, but this would affect innocent stockholders. However, these people bought their stocks presumably after a knowledge of the situation and should take the risk. Again, the rates might be materially reduced if we had a gas and electric board with any nerve. Finally, municipal plants could be established, which would take the sting out of this situation, and this has been done in many towns and cities. With all their graft and politics, which this latter course entails, the municipal plant is still a success, despite what the central-station lawyers and agitators proclaim, and it seems to me a feasible solution of the difficulty. The great trouble is that the public does not know how they are being fleeced, and the amount each month is comparatively so small that they do not care. W. G. S.

Oil Fuel in New England

By Charles H. Bromley

SYNOPSIS—Over two years ago the installation of a low-pressure turbine at the Jenckes Spinning Co.'s plant, Pawtucket, R. I., returned a net saving of $21,000 per year over power costs when running Corliss engines noncondensing. The boiler-room economy with coal as fuel contributed appreciably to this saving. Tests with oil as fuel for this plant have shown better economy, and the results are important owing to oil-fuel activity in New England. The factors that influence one's judgment as to which is best to use, coal or oil, are considered.

In *Power* for Dec. 1, 1914, the writer had an article briefly describing the plant of the Jenckes Spinning Co., Pawtucket, R. I., and giving performance data as obtained by tests conducted by the Massachusetts Institute of Technology. These data created considerable interest, as they showed what economies it is possible to effect by the use of a low-pressure turbine for existing mills. The boiler performance was excellent, considering that the operating conditions were not temporarily improved for the test period. The coal was Crozier-Pocahontas and had the following analysis as received: Moisture, 2.72 per cent.; volatile, 13 to 15.4 per cent.; fixed carbon, 77 to 86 per cent.; ash, 4.4 to 5 per cent.; sulphur, 0.55 to 0.77 per cent. The equivalent evaporation from and at 212 deg. F. per pound of dry coal was 11.10 lb. throughout the test (72 hr.) and the cost of steam per 1,000 lb. was but 18.2c. The coal consumption per horsepower-hour developed was 1.41 lb. over the test period, and the cost per horsepower-hour developed was 0.494c. and 0.662c. per kilowatt-hour. Fig. 1 shows the boiler room with oil fuel and Fig. 2 shows coal firing conditions.

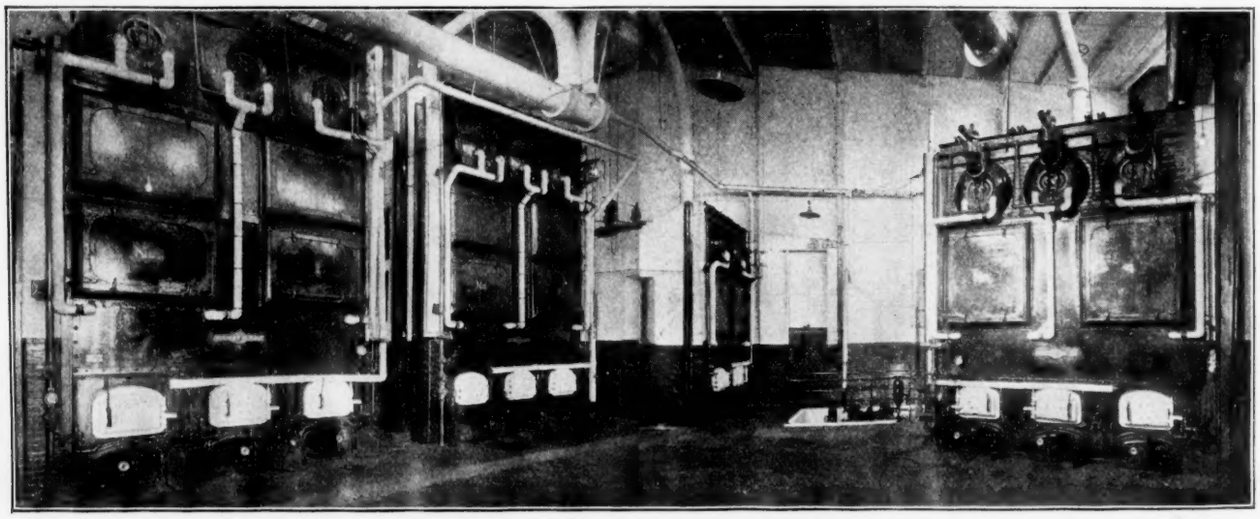


FIG. 1. THE BOILER ROOM WITH OIL USED FOR FUEL

The question of which is commercially better reduces chiefly to what oil costs per barrel and coal costs per ton in the community in question. But the oil company most active in New England is attacking the field on such a huge scale and offering such prices based on five-year contracts that, despite the disturbed political and industrial conditions in the country producing the oil, steam users have been particularly interested to know what oil would do as compared with coal; and for this reason the results with oil at the Jenckes plant are valuable. Fig. 3 shows the oil pump and heater at this plant.

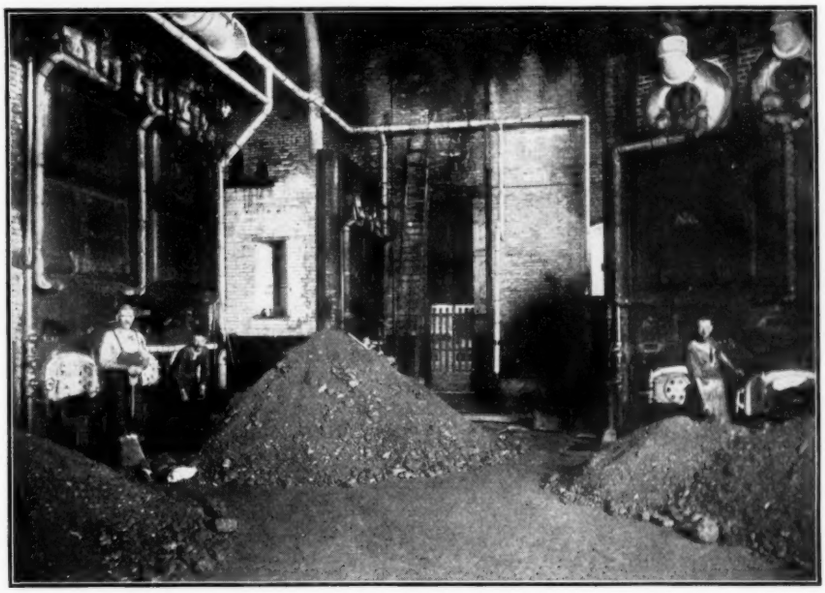


FIG. 2. WHEN COAL WAS THE FUEL USED

The European War has not been without its marked effect. New England coal, nearly all of it, comes into Providence and Boston by boats from Hampton Roads, Va. By May, 1915, all available sailing vessels were being chartered, and by October, 1915, the schooner-collier was a thing of the past as far as coastwise service was concerned. By December nothing in the way of barges or schooners was open to charter within many days. Of course marine freight rates took an enormous jump, reaching, as will be seen from the table, more per ton, Hampton Roads to Boston, than the price of coal f.o.b. Hampton Roads. The table tells much if carefully studied; it goes back beyond 1914 so as to show peace-time conditions. Then came a great rise in freight-car demand and a consequent congestion on the New York, New Haven & Hartford R.R. For maximum efficiency of freight handling this road could care for approximately 33,000 cars, while there were congested on the lines 52,000 cars. There was a serious shortage of cars and boats, and consequently of coal. Prices soared. Naturally, under these conditions fuel oil offered for 90c. per barrel on a five-year contract, with assured supply owing to the use of the oil company's own steamers running to large storage stations at Providence and Boston, appealed to steam-coal users.

The availability of coal barges, schooners, etc., together with a return to nearly normal in marine freight rates had no more than come when the present (Nov. 27, 1916) panicky market sent prices above what they had been in many years. Coal on cars at Boston (Dec. 5) was at the very high price of $9.50 and $10.00 per ton. No wonder there is interest in oil as fuel!

The performance of some of the plants that had changed from oil to coal had, of course, excited the interest of coal users. The Jenckes Spinning Co., which was contemplating a new mill for a subsidiary company, wanted to determine whether oil, coal or central-station service would be the cheapest source of power. For this purpose the Massachusetts Institute of Technology, which had made the remarkable performance test under coal (*Power*, Dec. 1, 1914), made a test with oil as fuel. The results were very gratifying and should be known to steam users.

A comparison of the results obtained in this test concerning the cost per kilowatt-hour and per horsepower-hour shows that an appreciable saving is made by the use of oil as fuel. The cost per kilowatt-hour output obtained in 1913, when the boilers were burning coal, was 0.662c., while that obtained in the present test was 0.605c., a gain of 11.20 per cent. This gain is almost entirely due to the change in fuel, as the other conditions at the plant are practically the same as when coal was used with the exception of the addition of the 300-kw. turbo-generator set. This addition might decrease the cost slightly in that it enables the 1,000-kw. generator to run more nearly at rated load by the additional exhaust steam supplied, and hence at a better efficiency. At the same time the load factor of the plant is increased, which would also decrease the cost. This item, however, cannot be considered in the comparison, since the fixed charges were not figured in either the 1913 test or the present one. The greater part of the decrease on cost may therefore be attributed to the change of fuel, and the result of this

RESULTS OF OIL ANALYSIS

Furnished by Mexican Petroleum Co.

Moisture, per cent	0.3
Sediment	Trace
Sulphur, per cent	3.56
Flash point (closed cup), deg. F.	178
Fire point (open cup), deg. F.	262
Specific gravity	0.960
Baumé gravity	15.9
Efficiency of boiler and furnace, per cent	78.4

COST OF EVAPORATION

Cost of oil per barrel of 42 gal. at 60 deg. F. delivered to storage tank, cents	90
Weight of gallon at 60 deg. F., lb.	8.020
Cost of oil per pound delivered to storage tanks, cents	0.267
Cost of oil per evaporating 1,000 lb. of water under observed conditions, cents	17.6

DISTRIBUTION OF COST OF POWER PER KILOWATT-HOUR AND PER HORSEPOWER-HOUR, CENTS

	Kilowatt-Hour		Horsepower-Hour	
	Day	Night	Day	Night
Cost of evaporation	0.471	0.470	0.352	0.350
Makeup water	0.017	0.018	0.013	0.013
Labor	0.082	0.063	0.061	0.047
Repairs	0.027	0.033	0.020	0.025
Oil and waste	0.014	0.017	0.010	0.013
Totals	0.611	0.601	0.456	0.448
Average	0.606		0.452	

The costs given do not include the fixed charges such as depreciation, interest on investment and insurance.

EFFICIENCY AND ECONOMY RESULTS

	Day	Night
Pounds of steam per kilowatt-hour	26.7	26.7
Pounds of steam per horsepower-hour	19.9	19.9
Pounds of oil per kilowatt-hour	1.65	1.65
Pounds of oil per horsepower-hour	1.31	1.31
Over-all efficiency of plant, per cent	10.5	10.5

YEARLY SAVING BY USE OF OIL

Weekly kilowatt-hour output	195,400
Yearly kilowatt-hour output	10,160,000
Cost per kilowatt-hour, exclusive of makeup water, cents	0.588
Cost per kilowatt-hour obtained in 1913 (coal), cents	0.662
Difference, cents	0.074
Yearly saving 10,160,000 × 0.00074	$7,500

Since in the year 1913 the cost of water was not included in the cost per kilowatt-hour, it was not used in this test when the yearly saving was figured.

change on each of the operating expenses affected will be considered separately:

Cost of Evaporation—As a direct result of using oil as fuel, the boiler efficiency was increased from 72.8 to 78.4 per cent., and therefore the cost of evaporation lowered proportionately.

Labor—Due to the ease of firing the oil-fed boilers, the number of firemen and helpers in the boiler room was decreased so that the cost of wages per week was reduced from $205 to $144.

It will also be observed in connection with the results of this test that the cost of power is slightly greater during the day than during the night. It is reasonable to suppose that as the load was not greatly reduced during the night, the efficiencies of the various units were not lowered by any considerable amount, so that this decrease was a little more than offset by the higher vacuum obtained during the night run, as shown by power-test data.

The cost per barrel of oil as compared with the cost of coal per ton is not the only important consideration when attempting to decide which is best for commercial, everyday use. There must first of all be assured continuity of supply. This involves a political and an economic situation, inasmuch as Mexico is perhaps the largest source of fuel-oil supply. The present political and economic disturbance in Mexico is of unusually long duration but is not alarming.

There should be provision for three or four month's storage, and the installation must be such as to meet insurance requirements and secure minimum rates. This means possibly underground storage removed appreciably from the boiler room.

COAL PRICES—NEW RIVER AND POCAHONTAS COALS

Date	F.O.B. Hampton Roads	On Cars		Freight Rates per Ton Hampton Roads to Boston
		Boston	Providence	
Jan. 27, 1912..	$2.70	$4.20–4.35	$4.10–4.35	$1.00–1.10
Feb. 17, 1912..	2.70–2.85	4.50–4.75	4.35–4.50	1.25
Jan. 13, 1913..	3.50–3.60	4.53–4.75	4.50–4.75	80c.
Feb. 22, 1913..	2.70–2.80	3.85–4.10	.....	95c.–1.00
May 10, 1913..	2.75–2.85	3.73–3.90	3.73–3.78	70c.–75c.
Aug. 2, 1913..	2.85–3.10	4.05–4.15	3.95–4.10	.....
Jan. 10, 1914..	2.80–2.90	3.72–3.82	3.72–3.78	70c.–75c.
Feb. 14, 1914..	2.80–2.85	3.58–3.65	3.58–3.68	70c.–75c.
May 2, 1914..	2.80–2.85	3.60–3.78	3.55–3.73	65c.–70c.*
May 23, 1914..	2.80–2.85	3.40–3.70	3.50–3.78	55c.*
June 13, 1914..	2.80–2.85	3.35–3.63	3.40–3.68	65c.–75c.
Nov. 7, 1914..	2.50–2.75	3.50–3.78	3.35–3.73	55c.–65c.
Dec. 26, 1914..	2.55–2.75	3.50–3.73	3.35–3.63	70c.–80c.
Mar. 13, 1915..	2.70–2.80	3.70–3.90	3.58–3.73	90c.–1.00
June 15, 1915..	2.75–2.85	3.70–3.78	3.60–3.73	75c.
Nov. 27, 1915..	2.80–2.85	3.65–3.83	3.63–3.78	1.10
Dec. 18, 1915..	2.85	6.00–6.25	5.75–6.00	3.00
Jan. 15, 1916..	2.85	6.75–7.00	6.75–7.00	3.25–3.50
Feb. 12, 1916..	2.85	5.50–5.75	5.50–5.75	.....
May 20, 1916..	2.80–2.85	5.15–5.35	5.15–5.35	.....
July 8, 1916..	2.80–2.85	4.80–4.90	4.80–4.90	.....
Aug. 12, 1916..	3.00–3.25	5.10–5.20	5.10–5.20	.....
Sept. 16, 1916..	4.00 and up	6.50–6.75	6.50–6.75	2.00
Oct. 14, 1916..	4.50	6.50–6.75	6.50–6.75	1.65–1.75
Nov. 11, 1916..	5.50–7.00	8.50–9.00	8.50–9.00	2.00
Nov. 18, 1916..	7.00–7.50	8.50–9.50	8.50–9.50	2.00
Dec. 5, 1916..	.....	9.50–10.00	9.50–10.00	.....

* Spot loading.

The Prime Movers Committee of the National Electric Light Association in its 1916 report mentions the possibility of the Government commandeering the vessels used for oil transportation. Such a thing may be remotely possible, but it is one of those items that must be considered by a large fuel user before making a change from coal to oil.

The United States Navy has adopted fuel oil extensively, some of the vessels not even being provided with coal bunkers at all. Should there be a shortage or possible shortage of this fuel for naval use in time of war or when war was imminent, the Government would of course assume control of most of the available supply regardless of private interests.

The coal market, in supply and in price, does not of course fluctuate like the fuel-oil supply and prices. We may therefore look for the price of oil to follow in the wake of coal prices, the oil dealers possibly keeping the quotation sufficiently below equivalent coal prices to make oil desirable from the heat units per unit of cost basis. That this is being done is evidenced by the increase in oil prices on five-year period contracts made since coal prices have increased due to marine-freight-rate increase and to a panicky market.

From the boiler-room standpoint there is little question of the superiority of oil over coal. The control of

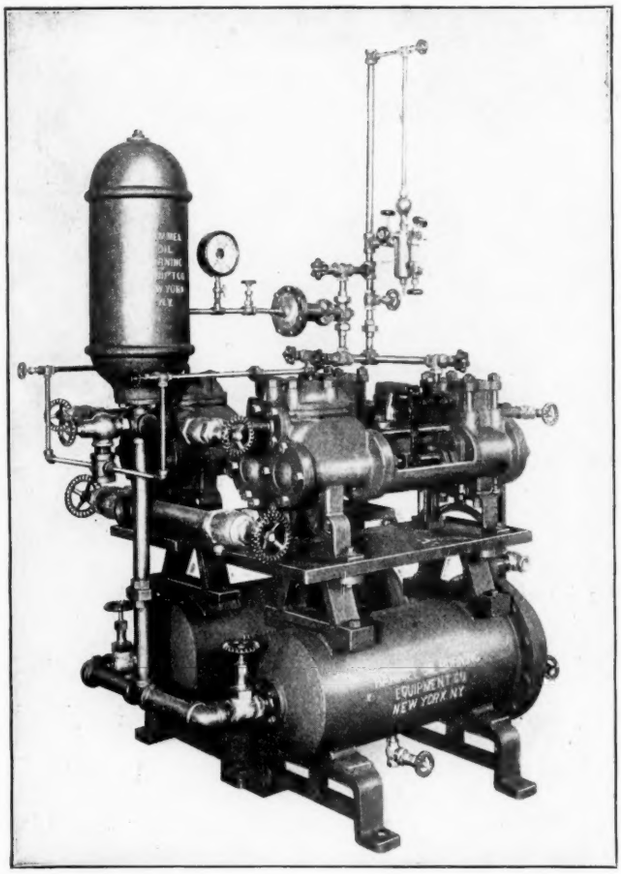


FIG. 3. OIL PUMP AND HEATER AT THE JENCKS PLANT

the fire is instantaneous and therefore extremely flexible. There is an appreciable decrease in boiler-room labor costs, particularly in large plants. As for first cost and total boiler-room maintenance costs, it is questionable if there would be any appreciable reduction. The supply and price would surely have to be well guaranteed at this time to convince a consulting engineer that he should not make provisions for coal and ash-handling apparatus and for draft apparatus in a proposed plant. The overhead on such equipment goes on whether it is or is not in use.

With the present high development of the underfeed stoker the one-time claim of superiority of oil for quick steaming and for the handling of sudden peak loads is obsolete.

In the average plant, with average men in attendance, there may be expected a higher boiler efficiency with oil than with hand-fired coal.

The classical Delray tests with coal gave 82.5 per cent. efficiency. Authoritative tests have shown oil to do better by a fraction of 1 per cent., and some reported tests with oil have shown as high as 83 and 84.5 per cent. in some Texas plants.

Editorials

American Uniform Boiler Law Congress

The American Uniform Boiler Code Congress held at Washington recently under the auspices of the Industrial Commission of Ohio seems to lead logically and irresistibly to one conclusion. The fact was established that governmental supervision of the construction, installation and use of steam boilers had resulted in a great diminution in the number of boiler explosions in foreign countries. The Industrial Commissioner of Kansas admitted that in ten months there had been eight boiler explosions in that state. Another speaker quoted statistics showing that in a whole year there were only the same number of explosions in the whole German Empire, and that in 1914 there were in that empire only thirty such explosions against five hundred and seventy-five in the United States.

The effectiveness of supervision having been thus established, Dr. Hutton showed in the admirable thesis presented in last week's issue that "an industrial accident—and a boiler rupture or failure is such an accident—is an economic loss and an indefensible blunder from which the community has a right to be defended, and by ordinance or legislation." The desirability, if not the necessity, of uniformity in governmental regulation was convincingly demonstrated. And then the eminent fitness of the Boiler Code of the American Society of Mechanical Engineers, an instrument which embodies the best thought of the best-qualified specialists in the land working in consultation with the interests affected, a work which, paid for at a fair estimate of the value of the time and labor involved, would have cost half a million of dollars, was convincingly established. It is hard to see how anybody who entered the congress with an open mind and thoughtfully followed its deliberations could have left without being convinced that every state should provide for boiler inspection and that the A. S. M. E. Code should be universally adopted as the standard to which boilers must be built and run.

Civil Service for Inspectors and Examiners

Now is the season when the man with the appointing power is beset by hordes of "outs" armed with all sorts of clubs for the fellows who are holding the positions which they feel that they would grace, and when the "ins" are wondering whether the Happy New Year will bring an assurance of appreciation or a request for their resignations. The appointment of barbers as boiler inspectors and grocers' clerks as examiners of engineers has made license and inspection laws a farce in more than one instance, and it was with a great deal of satisfaction that we saw the stress put upon the civil-service feature of the matter at the American Uniform Boiler Code Congress recently held at Washington.

The law will accomplish its purpose only if administered by one who knows the work to which the law applies. Heads of departments and examiners should be appointed only after a rigid investigation of their qualifications; and when they have been appointed and have made good, they should be continued as a matter of course and never be obliged to put time and effort that could better be used in the prosecution of the work of their departments into assuring their retention. Every month of service in work of this kind brings experience and increase of knowledge, to sacrifice which by a change of appointees is subversive of efficiency and of the feeling of stability and establishment under which a department of this kind does its best work and men become great in their respective lines. If you have a good man, not only let him alone, but assure him that he has a life's job so long as he is a credit to the department which he rules and to the state which he serves.

Refrigeration Safety Legislation and the A. S. R. E.

The first paper of the Tuesday morning session of the annual meeting of the American Society of Refrigerating Engineers dealt with oxyacetylene welding as applied to pressure vessels particularly. It was indeed a disappointment that discussion of this subject should have ceased as soon as it did. There may be a conscious or an unconscious desire to put off the discussion, in an official way, of this subject as long as possible. Psychologically, this is what one would look for, although it cannot be truthfully said that engineers are as guilty of this Pickwickian characteristic as is the public generally.

Of course there is a great deal that is disagreeable that is bound to come up during a discussion of the subject of autogenous and electric welding of pressure vessels, particularly for boiler and ammonia or refrigeration work. But this does not justify anyone putting off the day of proper consideration of the subject. It looked for a while as though another year would go by before the American Society of Refrigerating Engineers would again take up this subject and give it the consideration that it demands, but fortunately discussion was resumed later in the day. There should be no inclination to run away from a subject simply because the discussion of it will not read like a beautiful story.

In the statistical paper presented to the meeting by John E. Starr it was shown that the ratio of accidents to the number of plants and individuals involved is perhaps no greater in the refrigeration industry than it is in others. But his investigations of accidents occurring from 1910 to 1916 revealed that forty per cent. are due to ignorance and carelessness. The society should remember that the public will pay little heed to statistics but is aroused by a serious explosion or releasing of fumes, which may occur at any time. Under such circumstances some kind of safety legislation is demanded at once, and of course inadequate, silly or really dangerous rules are all too frequently made law, and are corrected only by a process notoriously slow. Do not the members of the

American Society of Refrigerating Engineers know that years of effort have been necessary to untangle the same kind of a situation, but related to boilers, that the refrigerating machinery industry is encouraging by the society's inaction or unsystematic action as related to a safety code? With the Boiler Code complete and after all the excellent influence upon legislatures and state officials by the American Uniform Boiler Law Society, most of the wrinkles are by no means ironed out of the boiler-laws situation.

For the refrigerating engineers the road ahead is practically clear, though it is quickly filling with obstacles. Massachusetts has an ammonia safety-valve law and is likely to soon enact a law relating to general safety in refrigeration plants; Chicago and Detroit have similar laws; New York City has its own peculiar refrigeration-plant requirements. It would not be surprising to see Commissioner of Labor Bryant of New Jersey and the Industrial Accident Commission of California soon come forth with proposed refrigeration safety rules. The society should take advantage of a vanishing opportunity to properly codify refrigeration-plant rules, and start by giving a strong stimulant to the present committee.

Temperature Measurements in Electrical Machinery

A paper was presented recently before the American Institute of Electrical Engineers, on "Temperature Distribution in Electrical Machinery," an abstract of which is published elsewhere in this issue. Thanks to the genius of the author, B. G. Lamme, this whole subject is presented in such a clear, concise and readable manner as to make one wonder why all the discussion of the past about temperatures in electrical machinery.

In analyzing engineering problems Mr. Lamme is an adept and has long been known for his ingenious methods—ingenious in their simplicity of presenting complex subjects. This, his latest presentation, is no exception and is a most excellent example of his work, giving a clear physical conception of heat distribution and the errors in temperature measurements in electrical machinery. Borrowing the expression of H. W. Buck, president of the American Institute of Electrical Engineers, "We are fortunate to have this paper presented in English and not in symbols," and such English that those with the most elemental knowledge of this subject can understand it. Mr. Lamme shows us why deep coils burned out when there was no apparent outside indication of anything being wrong on the inside. However, all was not well on the inside of the coil, because considerable difference of temperature existed between the inside and outside turns of the coil. Yet we kept on measuring the temperature on the outside surface as an indication of what the conditions were in the center. This temperature measurement did not give even an approximate indication of the internal temperatures especially if there were hot spots in the winding, and we now know that they did exist in the earlier types of electrical machinery and to a certain extent in the more modern apparatus.

The measurement of temperature by the resistance method is no more of an indication of the highest temperatures in the coil than that obtained by placing a thermometer on the outside of the insulation under a pad. The resistance method at best gave only an average indication of the temperature in the winding. The resistance-coil method, on account of the comparatively large size of the coil, gave only a relatively crude approximation of the temperature, although when introduced it was really an important step.

As Mr. Lamme points out, the thermocouple, owing to its small mass, can be placed in all sorts of normally inaccessible places in the windings and will follow very quickly temperature change where it is located. If properly placed, it furnishes the most accurate temperature indication that we now have, but is limited almost entirely to stationary apparatus. In rotating machinery it can be used only after the machine has been shut down, and this introduces an error due to heat flow. Temperature measurement in electrical machinery is far from an exact art at present. The methods in use are crude, but the engineer is no longer going at the problem blindly.

A Mutually Beneficial Christmas Gift

The Christmas spirit is in the air; an era of peace and good will reigns between the boss and workman, between the office and the engine room.

This is a condition which it is worth while to perpetuate, and nothing will go farther toward doing this than a little thoughtful recognition of conscientious service by the management at Christmas time.

The contact of subordinates with the management is too often negative and forbidding. When everything goes right there is no occasion for the owner or manager to communicate with them, and when they are summoned to the captain's office it is usually to explain why something has gone wrong. They get blame and reproof, but not so much of cheery commendation.

Why not take this chance to pat your engineer on the back by sending him a paid-up subscription to *Power* for the coming year? He will appreciate your expressed appreciation of him; he will be a better engineer for reading it, and you will spread the Christmas spirit and perpetuate this era of amity in the environ where it will do you the most good.

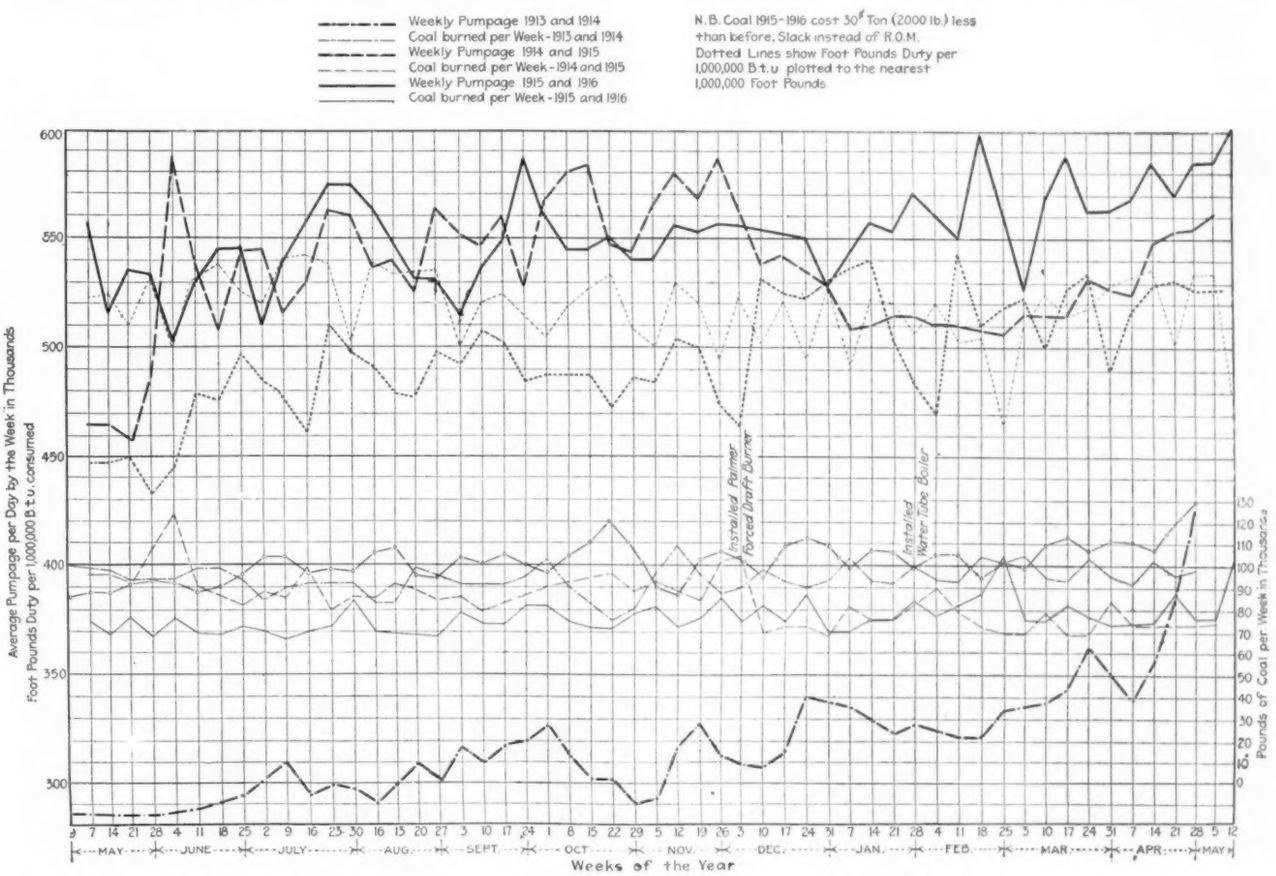
We will send with the first issue of any subscription ordered in this way an appropriate card explaining that the paper is to be sent for a year with the compliments of so-and-so and conveying to the recipient in the spirit of the times the good wishes of the sender.

All honor to the Commonwealth of Massachusetts and Deputy Chief of the Boiler Inspection Department George A. Luck. Massachusetts was the first state to have a boiler code or to carry out a systematic plan of boiler supervision. Its law and code have been adopted by or have been the basis of those adopted by most of the other political divisions that have made any serious move in this direction. Even the Code of the American Society of Mechanical Engineers is largely modeled in its image. It is therefore a particularly commendable act of self-repression for Massachusetts in the interest of uniformity and standardization to accept, as Deputy Luck announced at the Uniformity Congress at Washington that she would, this newer code; and her wish and preference in the few particulars in which the codes differ materially should be deferred to where possible and her experience with such a code be given full value when differences are discussed.

Correspondence

Work of a Pumping Station

The illustration shows a performance chart of a small pumping station. Though the curve shows a ragged efficiency line, it indicates that there has been a general improvement in the operation of the plant. The sudden breaks are caused, in most instances, by either one of two things; namely, the use of the old fire-tube boilers during a period of inspection and cleaning of the new boiler, or the speeding of the air compressors to regain water-storage supply or to keep up with the demand for more water.


Weekly Pumpage 1913 and 1914
Coal burned per Week - 1913 and 1914
Weekly Pumpage 1914 and 1915
Coal burned per Week - 1914 and 1915
Weekly Pumpage 1915 and 1916
Coal burned per Week - 1915 and 1916
N. B. Coal 1915-1916 cost 30¢ Ton (2000 lb.) less than before, Slack instead of R.O.M.
Dotted Lines show Foot Pounds Duty per 1,000,000 B.t.u plotted to the nearest 1,000,000 Foot Pounds
Average Pumpage per Day by the Week in Thousands
Foot Pounds Duty per 1,000,000 B.t.u. consumed
Pounds of Coal per Week in Thousands
Installed Palmer Forced Draft Burner
Installed Water Tube Boiler
MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC. JAN. FEB. MAR. APR. MAY
Weeks of the Year

PERFORMANCE CURVES OF FLORENCE, S. C., PUMPING STATION

When it is known that the equipment other than the water-tube boiler and forced draft is of uneconomical design for our purposes and out of date, the curves show that we are getting something for our money, even though it be only a part of what we should get. The coal consumed has been either New River or Pocahontas during the whole period and averages about 14,500 B.t.u. per pound.

The air lift is for a deep well with lift of 230 ft. to the reservoir; steam pumps take the water and deliver it to a standpipe 135 ft. high, making the total lift of 365 ft.

M'KEAN MOFFITT.

Florence, S. C.

Diesel-Engine Operation

Some years ago I took charge of a power plant consisting of three 225-hp. Diesel engines directly connected to 150-kw. generators. One was a direct-current machine and the other two alternating-current generators. This plant also had two steam engines belted to generators that were used as relays.

When I first entered the plant, one of the Diesel engines would carry only 90 kw. and another 105 kw. The only way the alternating-current Diesel-driven units could be thrown in parallel was to get full load on one and then cut in a steam-driven unit to take care of the load as it came on up to 100 kw. This load was then shifted to the second Diesel engine and the two generators thrown in parallel. It was evident that the engines needed attention. I rebored the cylinders, ground in the exhaust, admission and needle valves and otherwise put the engines in first-class condition. After this the Diesel units could be thrown in parallel on a 75-kw. load with safety, and each would carry 150 kw. besides pulling its own air compressor, which took about 20 kw. On a year's run the oil consumption averaged 14 oz. per kw.-hr. This was actual and took care of all losses. The writer operated these three Diesel units almost continuously for nearly two

years with only one delay in starting the direct-current machine.

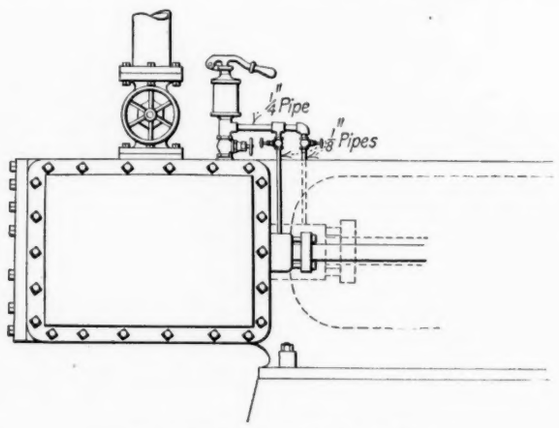
The Diesel engine is an efficient machine and will do good work if properly cared for, but unlike the old steam engine, it will not run on "three legs." Where trouble is experienced with this type of prime mover, it is more often traceable to the operator than to inherent defects in the design. In my travels I have found three kinds of engineers: One uses good judgment, examines his engines regularly and anticipates operating difficulties; another is always tinkering with the engine and finally gets into trouble; the third is afraid to touch a machine as long as it will operate for fear he will get into trouble, and eventually he is in real trouble.

Owing to the incompetence of the two types of engineer last-mentioned, machines are often condemned and sent to the scrap heap. The selection of competent engineers who would have made the best of the equipment at hand would have been more to the purpose.

Chicago, Ill. E. DANIELS.

Packing-Oiling System

Some time ago I saw an engine equipped as shown in the illustration. This engine is on 24-hr. service, and is shut down only when absolutely necessary. Trouble



OIL FORCED INTO PACKING

was experienced with the piston and valve rod packing burning out, and to overcome this as far as possible, the stuffing-boxes were drilled for ⅛-in. pipe and connected up to the oil pump as shown. The oil is applied much better than in the old way of putting it on the rod so that the first ring of packing wipes it off.

Amsterdam, Ohio. JACK L. BALL.

Arcing Caused Short-Circuit

In reply to W. G. Camp's article in *Power* of Nov. 21, wherein he asks for suggestions that may enable him to avoid future troubles with blowing fuses, ruined sockets and burned hands, the following may be of interest. Although the suggestions here given may enable Mr. Camp to prevent future troubles with his laundry circuits, they could no doubt have been more concisely expressed had he described the method of breaking the electric-iron circuit at the present time.

I recently had occasion to investigate similar troubles in a laundry where as many as twelve irons were used, and in nine out of ten instances the cause of fuse blowing was that the operator attempted to disconnect the cord from the iron instead of using the single-pole switch installed for that purpose.

It was found that the inside of the socket, to which the iron was connected, had become so carbonized from using it as a switch that poor contact was made, and owing chiefly to this carbonization, it was necessary to use considerable effort to free it from the iron. The blowing of the fuses was due to arcing from one contact to the other in the socket causing a short-circuit.

If conditions permit, I would suggest that instead of the operators disconnecting the iron at the sockets, they be instructed to use a single-pole switch or the lamp-socket key, depending on the installation.

Marion, Mass. J. E. HUDSON.

Government Regulation of Power-Plant Practice

On page 700 in the issue of Nov. 14 F. J. McMahon, telling of the economies effected by governmental supervision of chimneys and flues in Europe, decries the lack of such precautions in this country, but most of our progressive cities have laws directed against the production of dense smoke, generally enforced by engineers versed in combustion methods. These laws provide that the flue and the means for burning fuel shall meet the approval of this official.

In cities where this practice is in vogue great benefit accrues to the fuel user other than from the mere lessening of smoke and dirt. It is to be regretted that a few of the large cities have not yet seen fit to regulate these matters by law. MARTIN A. ROONEY.

Nashville, Tenn.

Oil-Siphoning Preventions

The matter of siphoning of transil oil, as discussed by Mathew King under "Leaky Transformer Cases" in your issue of Oct. 31, offers opportunity to consider this question a little more fully.

Practically every engineer who has had experience with oil-filled apparatus has encountered troubles from siphoning of the oil up the leads of such apparatus as induction regulators, transformers, reactances, etc. Sometimes this siphoning—which is apparently due to siphoning action and capillary attraction between the strands of the cable and the insulation—is responsible for false alarms as to leaky cases. This trouble is easily traced to the right cause. It is almost always accompanied by stickiness of the affected parts, the collection of dust and dirt and by stained floors. Oil has a very deleterious influence upon rubber, destroying its mechanical strength as well as its dielectric strength, or insulating properties, while also, increasing the fire risk to some extent. The sum total of this is that siphoning of oil is always undesirable.

The oldest method of overcoming the siphoning is to solder the strands of stranded cable together for half an inch or more, above the oil level. This was found to alleviate the trouble somewhat and was, I believe, patented by one of the transformer-manufacturing companies many years ago. The latest means of overcoming the oozing and seeping of oil along the leads of apparatus

is merely a modification on this method. It consists of inserting an air gap in the path of the oil flow above the oil level and is done as follows:

The insulation on the conductor is cut off for a length along the conductor of from two to five inches, the latter being preferable, and the edges of the peeled insulation are beveled off. If stranded cable is used, the strands are soldered together. Over the naked conductor is now slipped a sleeve of fiber, micarta or other equivalent insulating tube. Where the length of the conductor or its shape prevents slipping the tube along the conductor, the sleeve is made in two parts and clamped in place. This sleeve need not be thicker than necessary for mechanical strength, and when in position insulating tape, empire cloth or other binder is wound round it to hold it upon the cable.

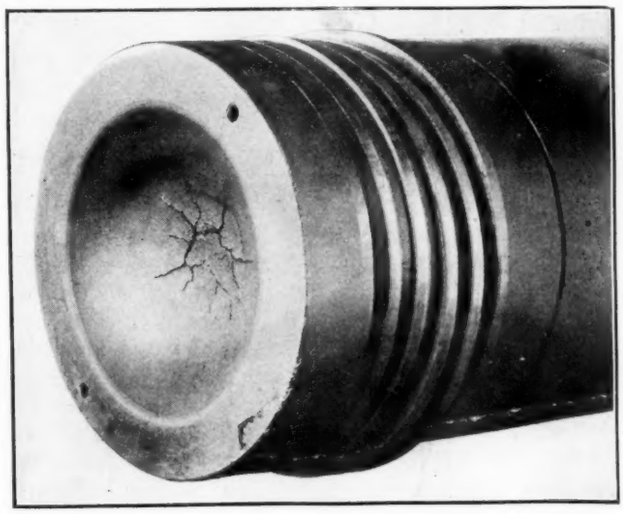
In making this type of nonsiphoning joint, holes have been drilled in the sleeve, these holes being left open with the idea that any oil oozing up into the gap might escape through them or that any tendency toward a vacuum would in this way be eliminated. Experience seems to show, however, that the joint without holes is as satisfactory as the one with them, while it has the advantage of being more easily made. The use of this joint will prevent siphoning and assure no loss of oil from this cause.

M. A. WALKER.

Chicago, Ill.

Record of a Diesel Piston

The photograph reproduced is of a piston of a Diesel engine that has been in continuous use for some 18 months, running 100 hr. per week, but discarded because it lost compression through the cracks to be seen in the



CONDITION OF DIESEL PISTON AFTER HARD DUTY

end. As soon as it commenced to show radial cracks, we drilled and tapped $\frac{3}{16}$-in. holes at the outer extremity of each crack and plugged them with mild steel. This usually prevented further extension of the crack; but as time passed, the edges of the cracks burned away, deepening the fissure till gases puffed through when starting up.

Every eight weeks we draw each piston, remove the rings, thoroughly clean off all carbon deposit and, with the exception of the oil ring, radius the external edges of each ring to prevent the rings seizing, due to carbon deposit. We also burn the lime out of the water jacket by filling the space with a 10 per cent. solution of muriatic acid, which eats away the deposit in about 4 hr. without injuring the iron.

The engine drives a very heavy swinging load, often full load, momentarily, 15 per cent. overload. The system of lubrication is not a forced circulating one, as in some of the more modern engines, but simply a ram lubricator to each cylinder; nevertheless, it is fairly satisfactory.

As regards lubrication, we use new oil for the gudgeon pin and cylinders and filtered oil for the main bearings and crankpins. The dirty oil is recovered from the base of the engine and is placed in a settling tank, from there passing into a steam-heated tank in which there is about 20 gal. of boiling water. Fifty gallons of dirty oil is fed into this tank at such a rate that a light yellow froth is maintained on the surface during the boiling-up process, which takes about 1 hr. After this is completed, the oil is allowed to settle and cool, the cleaned oil being drawn off and passed through a filter. Then about 7½ per cent. of new oil is added. This is a great economy, and we do not experience any trouble with hot bearings.

HENRY S. WHITELY.

Mill Hill, London, N. W., England.

Safety Head as Discharge Valve

The difference of opinion between Mr. Ledbetter (*Power,* Nov. 28, page 763) and Mr. Green (Sept. 26, page 463) seems to be that they are talking about different types of ammonia compressors. Vertical single-acting machines of small size are made with a discharge valve covering the whole end of the cylinder and acting as a safety head. Apparently Mr. Green's machine must be of this type.

With a larger machine, say 20 in. diameter, it is not practical to have the whole head act as a discharge valve. Imagine the pounding of a valve 20 in. diameter with 200 lb. per sq.in. above it and a spring strong enough to close it! Think of the weight and inertia effect of such a valve at 75 r.p.m.! To retain the safety feature and have a valve of more suitable size, the whole head is made so it can lift and springs are put in so it will not lift except in emergency. A valve designed to open and shut at every revolution, and of proper size, is put in the center of this false head. Mr. Ledbetter refers to this type of machine, and also A. G. Solomon, in his article, "Troubles and Care of Ammonia Compressor Valves," in the issue of July 18, page 92.

Mr. Green can rest assured that there is no objection to using the false head as a discharge valve on small compressors where it is designed to function as a discharge valve and only incidentally act as a false head. Mr. Solomon is correct in objecting to the use of a false head as a discharge valve on a machine where it is designed solely as a false head and not as a discharge valve. It is up to the designers to determine which sizes should be built which way. It is not abuse for Mr. Green to operate his machine as it was designed to run.

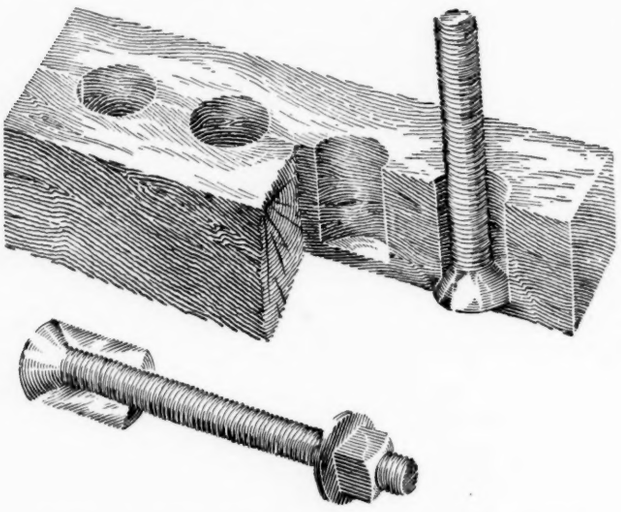
I would suggest that both Mr. Green and Mr. Ledbetter look through the catalogs of the builders of these machines.

HARRY D. EVERETT.

Washington, D. C.

Making an Expansion Bolt

Making an expansion bolt that is satisfactory, especially for light work, is an easy matter when done as follows: Make a mold by clamping together two blocks of wood and boring a hole (half in each block) the size



MOLD TO CAST LEAD SHEAVE AROUND A BOLT

of the hole into which the expansion part of the bolt is to go and the depth required. Into this mold place a stove bolt (any other kind will do) threaded well down toward the head as shown, and pour molten lead around it. When the bolt is placed in position and the locknut is tightened down hard, the lead will swage out and hold the bolt securely. A countersunk head will help the bolt to expand the lead sheath. F. F. Sengstock.

Chicago, Ill.

Feeding Boilers

I have given close attention to what readers have had to say in regard to the blistering or bagging of horizontal return-tubular boilers. Experimental data concerning feeding water into a boiler and its performance in regard to circulation and evaporation are very limited.

In 25 years of practical experience I have learned that it is unwise to introduce the feed water through the blow-off in the rear or even above the tubes in the rear, because its temperature is usually far below the point of evaporation, and when it strikes the shell and gets into the current of circulation, it is forced to the point where the greatest evaporation takes place. This would be over the grate or just in front of the bridge-wall, and if there should be any loose scale, it will all shift to this cyclone of evaporation and be deposited there on edge in a small mound, showing conclusively that a cyclone of evaporation does occur at that particular place for the want of equalization in temperature of the water along the bottom of the shell. This is all right with a clean boiler and distilled water, but it is too rapid evaporation for a few square feet of heating surface under ordinary conditions.

The direct cause of bagging is the sediment acting as an insulation, cutting off the water from the iron and allowing it to become overheated; but in giving down from internal pressure, the crust of the sediment will become disturbed and allow the water to reach the iron.

I want the feed pipe to enter just above the tubes and extend back to or just past the bridge-wall, with an open end and holes drilled in the underside 12 in. apart for uniform discharge. The result will be a uniform temperature throughout and no cyclone over the firebox, and if there is any at all, it will be at the rear where the blowoff can dispose of the sediment that is sure to collect where the greatest evaporation takes place. My injunctions are: Keep the bridge-wall well down; feed water regularly; blow out one to two inches of water twice a day when the boiler is doing the least work, and just before breaking up a banked fire in the morning, blow out good, and you will be surprised when washday comes. Gain information by making it a rule to be the first to look into the boiler when the manhead is removed for cleaning. C. H. Brown.

Pulaski, Tenn.

Favors Flat-Seated Pump Valves

In the issue of Oct. 17, page 566, Mr. Clevenstine asks which will give the better results in a feed pump, a bevel- or a flat-seated valve, and states that he has had considerable trouble with the flat type; but it is only a matter of conjecture what the nature of the trouble is, as he does not say. However, I assume that he has reference to the valves and seats getting cut. I would not advise him to use beveled seats if this is his trouble, as a flat-seated valve does not have to have the lift that one with a beveled seat does to discharge the same volume of water, consequently the closing will not be so severe.

We have a new 8x10x12-in. feed pump of the beveled-seat pot-valve type, the same design as is illustrated by Mr. Clevenstine. We thought we were "on easy street" but when we started it to work the speed required surprised everyone on account of the inefficiency of the pump valves; and in the course of a few weeks the valves and seats were fairly "chewed up" and the water surged back and forth and wore away the metal. After replacing them with flat seats screwed into the pot, it operated at only about one-quarter the former speed. We have used this type of valve on several other pumps with the same satisfactory results. H. T. Westwood.

Stratford, Ont. Canada.

Economy in Power Plants

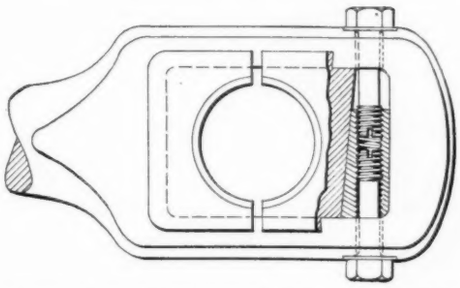
The suggestion in F. J. McMahon's letter in the issue of Nov. 14, page 700, regarding a boiler regulation prohibiting passing the gases to the chimney at 500 deg. F. or over, is a good one, and if coal continues to increase in price, owners will naturally pay more attention to the efficiency and economy of their power plants.

Coal operators expect that 1917 coal contracts will be made at one or two dollars more per ton than this year, which will unquestionably call for and lead to better boiler-room equipment and more care in operation in order to utilize the greatest possible percentage of B.t.u. in the fuel. Using coal that costs $5 a ton at the mine of the same grade that previously cost $3 will make a great difference. Boilers will have to be kept free from scale and soot; grates, settings, etc., will have to be maintained in top-notch condition, and fuel economizers used to save part of the heat that now goes up the chimney.

Philadelphia, Penn. A. G. Post.

Wedge-Block Adjusting Bolts

To diminish the breakage of wedge-block bolts, I reduce their size between the thread and head as shown in the illustration and have very little trouble. The clearance between the ends of the bolts is not over ¼ in. and is less on small rods. This with 1-in. bolts gives half



ADJUSTING BOLTS TURNED SMALL IN MIDDLE

the outside size of the stub end, less 1¼ in. for spring or the slight motion of the wedge, instead of a very short piece of threaded bolt to take this strain.

Washington, D. C. HARRY D. EVERETT.

Diesel-Engine Comments

In a recent issue of *Power* there appeared a couple of articles, one affirming and the other denying that Diesel engines are unsatisfactory. Permit me to pass a few comments, which are as unbiased as possible.

Diesel engines that have come within my observation indicate that some may be subject to serious troubles such as broken crankshafts, cracked cylinder heads, broken valves and worn pistons and cylinders. The root of these troubles seems inherent in the high pressures within the cylinder. To withstand these enormous pressures, all parts are required to be especially strong and heavy, and it becomes a difficult problem to keep boxes tight without burning and cool without pounding. The least bit of pounding rapidly becomes worse. The only remedy is to constantly and untiringly keep after such an engine with skilled mechanics, to nip in the bud the very first sign of trouble and save in time the proverbial nine stitches. Taking a small or moderate-sized industrial plant in the Middle Atlantic States, let us compare the steam plant with the Diesel. The boiler and steam engine combined, with necessary auxiliaries, will probably cost initially less than would a Diesel. The actual cost of operation, fuel, labor and supplies undoubtedly favor the Diesel, considering only the matter of obtaining energy in each case. But we must not forget the Diesel repairs. Further, most such plants require some steam for manufacturing and certainly all require some steam for heating during cool weather. Here the steam engine shines, as the energy then is obtained at very small cost. Balancing costs for periods of years, the Diesel engine does not show the saving popularly accredited to it. In any power plant the most vital requirement besides insuring oneself of sufficiency of power is to provide reliability. Loss in production caused by a single delay of a few hours mounts to untold loss and quickly wipes out any fuel saving one may figure on.

These ideas, while not quite favorable to the Diesel engine, are meant to inspire caution when estimating and particularly to dispel some of the popular illusions that may exist in this connection.

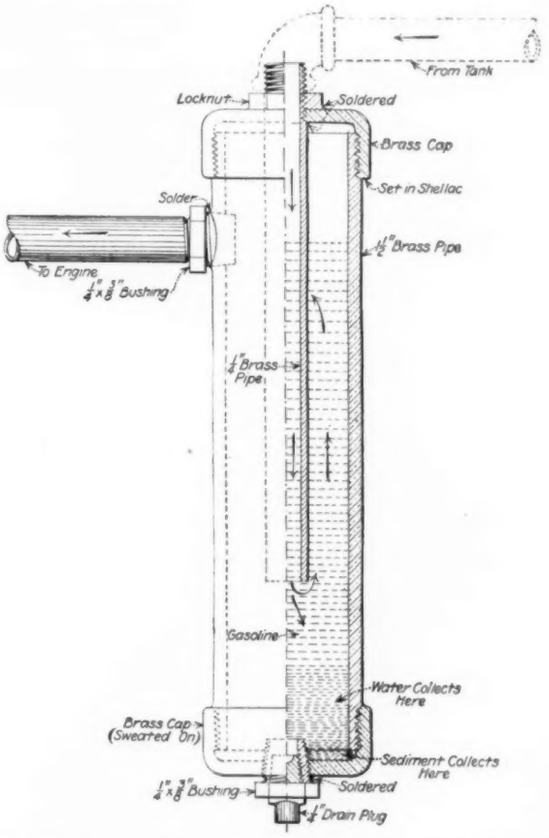
Before dismissing the subject I might add that many Diesel-engine operators probably have encountered difficulty in starting the engine on a cold morning. The scheme adopted in one plant to overcome this was to attach a steam pipe to the jackets and thus keep cylinders hot overnight. Considerable difficulty in starting a worn engine was successfully eliminated by this method. R. H. KENT.

Lansdowne, Penn.

[While the troubles mentioned were undoubtedly prevalent in many of the earlier engines, they can hardly be said to be characteristic of later designs unless carelessly operated.—Editor.]

Separator for Gasoline Line

A water separator made as described and shown has been used for about seven years in the fuel line of a marine-type heavy-duty oil engine to remove the water, etc., that sometimes gets into the tanks as well as sedi-



SEDIMENT-SETTLING CHAMBER IN OIL-SUPPLY LINE

ment contained in the fuel oil, which is not strained. No water, dirt or sediment from tank scale ever gets to the carburetor, even when the mixture is "riled up" in a seaway. The separator should prove satisfactory on any gasoline or kerosene engine.

The construction is fairly simple. In this case the body is made of 1½-in. brass pipe and two brass caps, the lower one being sweated on while the upper is set in shellac so that it may be removed. The upper cap is drilled and tapped for ¼-in. brass pipe, having a running

thread on the upper end. It is threaded up through the cap and has a locknut on the outside, to increase the bearing surface of the threads, and the whole is sweated together. This forms a connection for the fuel pipe from the tank. This ¼-in. pipe should extend to within about 2 in. of the bottom of the large pipe. The lower cap is drilled and tapped for a ⅜-in. bushing which is securely soldered in and a ¼-in. drain plug or a key-cock is screwed into it. On the side of the large pipe near the top another bushing is screwed in and soldered, thus making a connection for the fuel pipe to the carburetor.

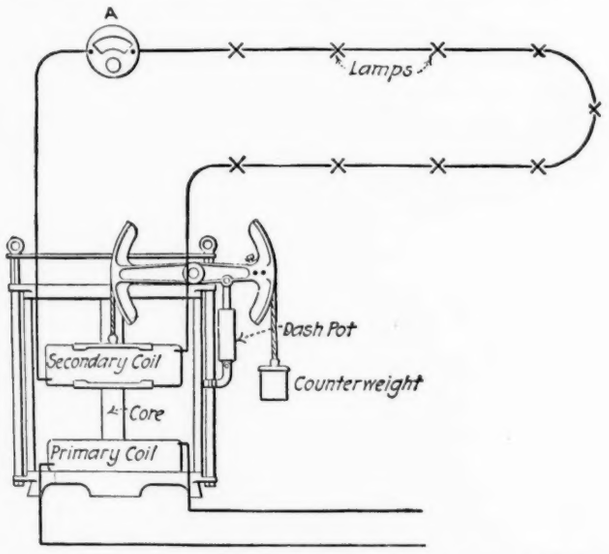
In operation the water and sediment settle to the bottom, while the clean fuel rises to the outlet pipe. The separator, of course, may be made any size; the larger it is the more dirt and water can be allowed to collect before draining.

H. H. PARKER.

Oakland, Calif.

Voltage Low at Constant-Current Transformer

The amount of current in the primary coil of a constant-current transformer depends primarily on the voltage applied to its terminals; as in the case of any transformer, it depends also on the amount of secondary current. The secondary current of a constant-current transformer is practically constant for a given weight of



CONSTANT-CURRENT TRANSFORMER DIAGRAM

counterbalance, after the current has become steady, but during the period of adjustment preceding regulation it depends on the resistance of the secondary circuit. The secondary, or movable, coil shown in the figure is so counterbalanced that when the transformer carries its rated secondary load, the stationary and movable coils are close together; for it is then that the greatest secondary voltage is required, so that the secondary coil must include as many as possible of the magnetic lines of force due to the primary. The greatest magnetic flux is included by the secondary coil when the two coils are closest together. Also, if the primary voltage is below what it should be, the primary current will be less for a given position of the movable coil and the repulsion between the coils will be correspondingly reduced; therefore the weight of the movable coil will force it nearer to the stationary coil, so that the current may be maintained at the value corresponding to the particular adjustment.

A small hydro-electric plant transmitted energy at 2,300 volts to a town seven miles distant, for series incandescent-lamp street lighting. At the receiving end the energy was transformed from 2,300-volt variable current to 230-volt constant current, by means of a small constant-current transformer. Complaint was made that the street lights were not satisfactory and that the constant-current transformer was overheating. An inspector investigated the conditions, and found that the transformer was operating with the coils together, but that the secondary current was low, therefore the street lamps were below normal brilliancy. As the outfit had no name-plate, the rating could be only approximated; on cutting out about one-sixth of the lamps, the remainder operated satisfactorily. The failure to give standard lamp brilliancy was then attributed to an overload, but the owner insisted that this could not be so because a unit of the same size, located in the generating station, was doing the same amount of work satisfactorily. As this argument was more suggestive than convincing, the inspector at once brought a potential transformer from the station and measured the primary potential difference at the current transformer; it was 20 per cent. low. The situation was relieved by installing a potential transformer giving a higher voltage on the secondary.

E. C. PARHAM.

Brooklyn, N. Y.

Some Criticisms

At the bottom of page 541 in the issue of Oct. 17 there is a short paragraph containing the statement that the power gained by the use of movable pulleys is ascertained by multiplying the number of movable pulleys by 2. This is wrong in two particulars: First, force or leverage and not power is gained, and second, the extent of the gain is found by multiplying by the number of ropes shortened or by the number of ropes that engage the moving pulley.

The rule for finding the sizes of steam pipes for reciprocating engines, given on page 582, Oct. 24, is to be criticized because the velocities given are computed on the basis of the engine under consideration taking steam throughout the whole stroke. On the assumption of a steam velocity of 6,000 ft. per min., a pipe of one-half the area given in the example would suffice, as engines rarely cut off at over one-half stroke. Modern practice favors higher steam velocities, as the decreased radiation losses, lower maintenance cost, the lower interest on investment and the drier steam delivered offset the loss due to drop in steam pressure.

G. E. MILES.

Green River, Wyo.

[The basis of the rule referred to is "operating at full stroke," but it allows for variation in velocity. For a given horsepower an early cutoff calls for more steam momentarily, consequently a higher velocity in a given pipe, although a receiver of liberal capacity near the engine helps to steady the flow. The most economical pipe size was not, however, the subject of the paragraph referred to.—Editor.]

Connecting-Rod Lengths depend much on the design and duty of the engine. For large stationary engines the length of the rod is 2½ to 3 times the stroke of the piston, if space permits; on smaller engines the ratio is sometimes reduced.

Inquiries of General Interest

Flow Over 60-deg. Notched Weir—What is the formula for flow of water over a notched weir when the angle of the notch is 60 deg.? A. D. C.

The flow of water over a symmetrical notched weir in thin plate is substantially the same for 60 deg. and 90 deg. and is given by the formula,

$$Q = 2.54 \times \sqrt{h^5}$$

in which Q = Discharge in cubic feet per second, and h = the depth, in feet, of the apex of the notch below the level of quiet water in the tank, pond or reservoir.

Reinforcement of Rectangular Concrete Tank—In the construction of an 18x40x20-ft. reinforced-concrete tank, practically all in the ground, where the reinforcing bars are placed 24-in. centers one way and 6-in. centers the other way, should the bars that are 6-in. centers be placed vertically or horizontally? W. L. S.

Vertical reinforcing bars would be of value in strengthening the sides as retaining walls, but where the tank is in the ground with a back filling, resistance of the sides as retaining walls would not be of serious importance and there will be greater benefit from placing the closer reinforcing horizontally for the purpose of meeting the weakening effects of expansion cracks.

Hard and Soft Boiler Patches—What is the difference between a hard patch and a soft patch for a boiler, and under what circumstances are they used? A. E. A.

A hard patch is a piece of steel plate accurately shaped and permanently riveted to replace a portion of the boiler shell, such as where a part of the shell has to be removed on account of the plates having become cracked or bulged. A soft patch is usually applied only temporarily or in an emergency and is not supposed to provide a permanent repair. The material of soft patches usually is soft iron or steel fitted to place by hammering cold and set in boiler putty or with lead gaskets and secured on the outside of the boiler by threaded patch bolts.

Length of Crank from R.p.m. and Piston Speed—What would be the formula for finding the length of crank in inches if the number of revolutions and the feet of piston speed per minute of an engine are given? C. H.

As the stroke equals twice the length of the crank and there are two strokes per revolution, then

$$2 \times \frac{\text{crank}}{12} \times 2 \times \text{r.p.m.} = \text{piston speed, ft. per min.}$$

hence

$$\text{Crank in inches} = \frac{\text{piston speed, ft. per min.} \times 12}{4 \times \text{r.p.m.}}$$

or

$$\text{Length of crank in inches} = \frac{\text{piston speed, ft. per min.} \times 3}{\text{r.p.m.}}$$

Dependable Discharge of 6-in. Pump—What is the formula for the number of gallons per minute discharged by a pump, and what would be the dependable discharge of a double-acting pump having a 6-in. diameter piston operated at a piston speed of 100 ft. per min.? H. B.

Neglecting slippage, the formula for the discharge would be,

Gal. per min. = Net area of piston in sq.in. × piston speed, in feet per min., × 12 ÷ 231

In the ordinary operation of a pump of the size quoted, it would be no more than safe to assume an allowance of 10 per cent. to cover slippage and reduction of piston area by the piston rod. So that, with a 6-in. diameter piston and piston speed of 100 ft. per min., the dependable discharge would be $[(6 \times 6 \times 0.7854) \times (100 \times 12) \div 231] \times (100 - 10)$, or about 132 gal. per min.

Cushioning of Duplex Steam Pumps—How is cushioning obtained and adjusted in a duplex pump? R. C. M.

In the ordinary duplex pump each steam cylinder is provided with two sets of ports, the outer ports acting for steam admission and terminating at the ends of the cylinder, and the inner, or exhaust, ports terminating a short distance from the cylinder heads. The piston, in approaching the end of the cylinder, covers the exhaust port, and any exhaust steam then in the end of the cylinder and the steam passage becomes compressed and, acting like a cushion, absorbs the momentum of the piston. The space between the outer edge of the exhaust port and the head of the cylinder forms the principal cushioning space, but there is no convenient method of changing this distance to adjust the cushion. On the larger pumps the steam and exhaust passages are connected by a passage controlled by a valve that can be opened for escape of some of the compressed steam to the main exhaust, should the piston cushion too heavily.

Corliss Engine Friction—What would be the relative friction load of an 18x42-in. and a 20x42-in. Corliss engine? F. W. M.

Other things being equal, the friction load of an engine varies with the weight of the parts, the character of workmanship and material, and the adjustment and lubrication of such rubbing parts as valves and valve gearing, piston rings, stuffing-boxes, connecting-rod brasses and main bearings. Small differences of material, workmanship or adjustment may be responsible for a wide percentage of variation of the friction, although the maximum may be only a small percentage of the full load of the engine. Running with the same piston speed, steam pressure and other conditions, excepting size of parts, the friction of the 18-in. engine would be to that of the 20-in. engine as 18^2 to 20^2, or there would be about 22 per cent. more friction for the larger engine. For a piston speed of 650 ft. per min. under average conditions, the friction of an 18-in. Corliss engine should be about 12 i.hp. and of a 20-in. engine about 15 i.hp.

Classification of Coals—What is the classification of coals as anthracite and bituminous based upon? B. R. C.

Coal usually is classified according to the proportion of volatile matter that it contains. The United States Geological Survey makes the following classification according to the percentage of volatile matter contained in the total combustible:

Anthracite, when the volatile matter is not more than 7½ per cent. of the total combustible; semi-anthracite when 7½ to 12½ per cent.; semi-bituminous when 12½ to 25 per cent.; bituminous, when 25 to 50 per cent.; and lignite, when the volatile matter is over 50 per cent. of the total combustible.

Geographically, the coals of the United States may be roughly classified as follows: Eastern Pennsylvania, generally anthracite; central portion of the Alleghany-Atlantic Valley as semibituminous; western Pennsylvania with those of the Southern States and Mississippi Valley as bituminous with the percentage of volatile matter generally increasing in the West and Southwest; and as lignite coals mostly those in the regions of the Northwest.

Pitch of Stay-Bolt Rows for Flat Surfaces—In staying the flat firebox sheets of a locomotive type of boiler, where each stay-bolt supports 25 sq.in. of plate, why would it not be proper to space the stay-bolts on center lines 12½ in. apart one way and 2 in. apart the other way rather than space them 5 in. apart each way? S. A. C.

The spacing must be made suitable to the thickness of the plate and the pressure, as well as for the load that can be carried by the stay-bolts. In a continuous flat plate uniformly loaded and supported at a series of points that are pitched on rectangles or squares, in the usual manner of arranging stay-bolts, the stress corresponding to the maximum strain is found to be indeterminate when the spacing between the rows in one direction is different from the other. Safety therefore requires the assumption that any strip of the plate connecting two adjacent rows of supports is in the condition of a beam fixed at the ends, and that the resistance of the plate depends on the broader spacing taken as the span between supports. Hence the usual formulas for staying flat surfaces provide for the "maximum pitch measured between straight lines passing through the centers of the stay-bolts in the different rows, which lines may be horizontal, vertical or inclined." Therefore, if each staybolt is suitable for staying an area of 25 sq.in., the rows may be pitched 2 in. by 12½ in., but the resistance of the plate is not to be considered as greater than if the stay-bolts were pitched 12½ in. by 12½ in.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Temperature-Measurement Errors in Electrical Machinery*

By B. G. Lamme

SYNOPSIS—The effect of rapid heat flow on the equalization of temperatures and on their measurement is considered, and some of the fallacies in temperature guarantees and temperature indications are pointed out. The more common errors in the methods of measurements are described.

When there are hot spots, or zones, or areas of different temperatures, in an armature winding, for instance, such difference in temperature is maintained by the continual generation of heat in the various parts. But the moment that such generation of heat is stopped, there is immediately a tendency to equalization of temperatures by flow of the stored heat from the hottest parts to the coolest. In good heat-conducting materials, as copper, such equalization may be very rapid, so that a temperature-indicating instrument of a sluggish type may not indicate anything like the true maximum temperature of the spot where it is placed, if applied after a load is removed, especially if the rate of heating the thermometer bulb is much less than the rate of heat transference from one part of the winding to another. If located on a hot spot, the reading may rise to some intermediate value and then drop off as the hot spot cools by heat conduction to other parts. If located upon a cool spot, it may rise slowly for a considerable period, due partly to sluggishness of the thermometer and partly to the cool spot rising in temperature by conduction of heat from some other part. The conditions are so varied that no reliable conclusion can be drawn from the action of the thermometer alone in regard to the coolest or hottest parts.

A second condition that tends to make such temperature measurements fallacious, lies in the cooling action of the interval between loads removed and shutdowns to take temperature measurements. In apparatus that depends upon a high degree of artificial cooling such cooling effects may be varied considerably. This is particularly true of high-speed machines that require considerable time to come to a standstill. It is therefore desirable in such machines to obtain all possible temperature readings at normal speed and with load. In rotating-field machines this is to a certain extent practicable, but in most rotating-armature machines the armature temperatures usually are not obtainable until the machine is brought to a standstill, and even then some error may result from sluggishness or delay in taking the readings.

One method that has been proposed at times for lessening the sluggishness is to heat the thermometers up to practically the normal operating temperature of the part to be measured, while the machine is still carrying load. At the moment of shutdown the heated thermometer is applied. This, to a certain extent, removes the factor of sluggishness in the thermometer itself, but it is only a partial compensation. It must be considered that the outside of the insulation is at a lower temperature than the inside; therefore, the body of the insulation itself must have its temperature increased by flow of heat from other parts.

In the older methods of determining temperatures it was assumed that the thermometer readings obtained on a winding, for instance, were a true indication of the temperature of the winding as a whole. The manufacturers of electrical apparatus long ago recognized the fallacy of this method, as they have found from bitter experience that there were liable to be hotter parts in the machine than any thermometer reading would indicate. They therefore designed machines with regard to the possible hot-spot temperatures as encountered in service rather than any temperature that the exposed parts of the machine would show. Thus, in designing a certain machine for safety at the hottest part, not infrequently the exposed part of the winding would show by thermometer comparatively low temperatures such as 25 to 35 deg. C. rise. Therefore, as the observable temperature reading came so low, it became the fashion to call for 35-deg. C. guarantee; and in many cases the operating public lost sight of or perhaps never knew the real meaning of such low temperatures. Among the designers of electrical machinery it was recognized that a temperature rise of 35 deg. C. was in itself absurdly low, but that the object in operating at such low temperatures on a part that could be measured was simply to protect the machine in some inaccessible hotter part where the temperature could not be measured.

From the present viewpoint it is astonishing what reliance has been placed on temperature readings in the past. For example, if a 40-deg. C. machine showed 41.5 deg. C. rise on test it was unsafe, while if it showed 38.5 deg. C. rise it was good. We now recognize that neither of these temperatures is a controlling value unless many other conditions are known. To the experienced man they simply mean that, compared with the other machines of similar construction and characteristics, which have proved satisfactory in service, they are reasonably safe. To the designer they mean that, when proper corrections have been made for the various internal temperature drops, the highest temperature attained at any point will be within the limits of durability of the insulating material used.

The whole problem of temperature measurement is a good deal like that of a determination of the voltage generated in a given power house by measuring the voltage at the end of the transmission line. If we know all the constants of the line and know the current flowing, etc., we can figure back to the generated voltage. Otherwise, the voltage at the end of the line means little. However, we know that if the system is designed with reasonable regard to economy in general, there may be some 10 or 20 per cent. voltage drop from the power house to the end of the line. Therefore, by adding an approximate correcting factor to this voltage we can make a reasonable estimate of the generated voltage. In the same way, in electrical apparatus of certain types a reasonable internal temperature drop may be approximate, which added to the observed temperature yields a fair approximation to the hottest part; but the result is an approximation and must be recognized as such.

Primarily, the manufacturers must make a safe machine for a specific service, regardless of the temperature guarantees, and the temperature measurements made on most classes of apparatus would be considered simply as rough approximations to indicate that the manufacturer has made a reasonable attempt at a safe machine. This may seem a rather bold remark, but nevertheless it is a fair statement of the case.

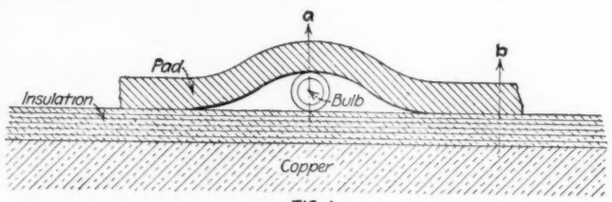


FIG. 1

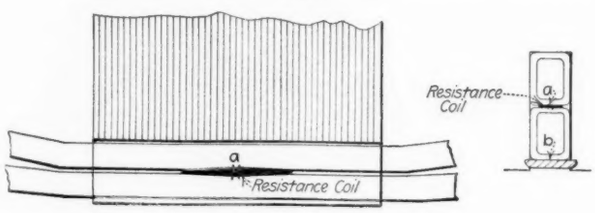


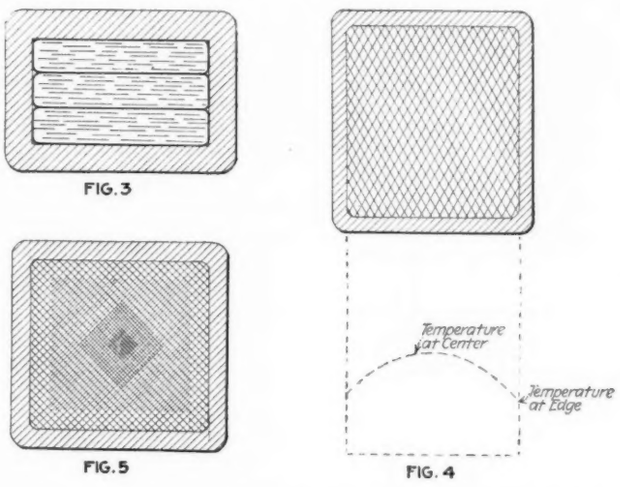
FIG. 2

FIGS. 1 AND 2. LOCATION OF TEMPERATURE-MEASURING DEVICES IN ELECTRICAL MACHINES

It has been shown in the preceding paragraphs that the usual observable temperatures are in most cases only crude approximations to the real temperature conditions. It may now be shown that even the observable temperatures obtained by the usual means are in themselves only crude approximations in many cases. Take, for instance, the determination of temperatures by increase in resistance. When the coil is heated, this temperature may not be and very

*Abstract from a paper, "Temperature Distributions in Electrical Machinery," presented at the Chicago Section of the A. I. E. E., Nov. 27, 1916.

frequently is not uniform throughout the coils. As an extreme example, if 0.2 of the coil's length has a temperature of 80 deg. C., while 0.8 of it has a rise of 30 deg. C., then the increase in resistance of the coil as a whole will correspond to a rise of 40 deg. C.; thus, by increase of resistance the temperature may be more than safe, while actually 0.2 of the coil is far above the safe temperature for ordinary fibrous insulations. In other words, the resistance method gives only average results and may be very misleading. However, in those cases where it is known by past experience and otherwise that there is very little liability of hot spots the resistance method of determining temperatures is often quite



FIGS. 3 TO 5. THE EFFECTS OF HEATING IN MANY CONDUCTOR COILS

satisfactory. However, the method is limited to comparatively few types of winding.

Considering next the thermometer method of measurement, the theory of this is quite simple, but apparently it has been very much misunderstood. In windings, except in rare cases, the thermometer is not applied directly to the heated generating material itself, but is applied outside of an insulating covering. Usually, the temperature drop through this insulating covering does not receive any consideration, and yet everything depends upon this.

Assume, for example, an insulated coil, thermometer and covering pad, as shown in Fig. 1. Assume that the copper inside is of uniform temperature and that the cooling air at (a) and (b) is also at a uniform, but much lower, temperature than inside the coil; then the temperature drop from the copper to (b) will be the same as through the insulation, thermometer bulb and covering pad to the air at (a). Obviously, if the temperature drop through the insulation and that through the pads are equal, then the thermometer bulb will show a midway temperature. This is of course assuming that the surface drop to the air previously referred to is very small, or that it is included as part of the drop through the pad. Then if the drop through the covering pad is made very much higher than through the insulation proper, the thermometer bulb more closely approaches the proper temperature. Thus it is seen that all kinds of results may be obtained, depending upon the relative drops through the pad and through the insulation.

In a low-voltage machine with relatively thin insulation the pad may take some of the drop. With very heavy insulation the pad may take proportionately less, and the thermometer reading departs accordingly from the copper temperature. It might be suggested that a big thick pad of poor heat-conducting material might be used. This apparently would tend toward more accurate temperature readings, but on the other hand harmful effects may be introduced by the use of large pads. The resistance to heat dissipation being increased in the area covered by the pads, obviously less heat will be carried away at this point, and therefore the heat generated under the pads must be conducted to adjacent parts of the coils. This means an increased temperature at this point, due to the use of the pads. Again, the use of the pad in some cases may effect the normal ventilation of certain parts of the coil more directly covered by the pad. For instance, if there is a ventilating space between two adjacent armature coils through which air is normally driven, a pad that covers this space even partially may create more or less of an air pocket and thus materially affect the heat dissipation and the temperature directly under the pad.

Experience has shown that both of the above conditions are obtained where good judgment is not used in the application of the covering pad. This, of course, applies particularly to those cases where temperature readings are obtained while the machine is in operation. Of course, after shutdowns most questions of ventilation and of generation of higher temperatures under the pad need not be taken into account.

There are so many conditions entering into the interpretation of the thermometer and resistance methods of determining temperatures that in certain classes of apparatus it has been very desirable to find more accurate methods. One of these is in the use of so-called resistance coils. In this method a coil of fine wire of known temperature coefficient and of known resistance at a given temperature is located at the place where the temperature is to be measured, and the temperature rise is determined from the increased resistance of the coil.

One serious objection to this arrangement is that the resistance coil must have considerable length and breadth, so that it really indicates the average temperature of a considerable area instead of a point. When placed between two coils, as indicated in Fig. 2, it usually occupies so great a proportion of a slot that it indicates an average temperature considerably lower than at (a). Furthermore, on account of the length of the coils there may be a considerable difference between the temperature at the two ends. Thus the resistance coil, like the resistance measurement of the windings themselves, gives an average result; but this average may be limited to a comparatively small area, whereas in the resistance method in general the indicated rise is an average of the whole winding. However, in the resistance method the temperatures of the conductors themselves are measured, whereas with the resistance coils the temperature measurement is outside the insulation.

MEASURING RESISTANCE BY RESISTANCE COILS

The resistance-coil method is therefore a relatively crude approximation, although when brought out it was really an important step in advance. In its early application many misleading results were obtained, due largely to lack of understanding of the principle governing temperature distribution and temperature drop. In some cases the resistance coil was placed under the wedge, as at (b), Fig. 2. In other cases the coil was placed at the side of the slot next to the iron or at the bottom. Very rarely was it placed midway between the two coils, probably because it was a more difficult application and also because the greater accuracy of such location was not recognized.

From the use of resistance coils many good engineers drew the conclusion that the upper limit of permissible temperature for fibrous insulation was only 80 to 90 deg. C., because with the coil located in certain ways and places deterioration of insulation at some other point was liable to begin if the above temperatures were exceeded. The error was in not recognizing the temperature drop between some hotter spot and the average location of the resistance coil. When this condition was recognized, the result obtained by resistance coils became more consistent with the facts.

A later development than the resistance coil is the thermocouple as a practical device for measuring temperatures. One great advantage of the thermocouple is its very small size, so that it can indicate the temperature at practically a point instead of a very considerable area. Moreover, as it is a zero-current method of measurement when used with a potentiometer, no question of size or length of the connecting leads need come up. The thermocouple is so small and has so little mass that it can follow very quickly any temperature changes where it is located. If properly placed, it furnishes the most accurate temperature indicator that we now have, as it can be located in all sorts of normally inaccessible places. However, its use is practically limited to stationary apparatus; in rotating apparatus or rotating parts it can be used only after a shutdown, which introduces errors, as already shown.

In all the preceding considerations it has been assumed that the copper inside the coil itself is at a uniform temperature in any given unit of length. This is practically true, provided the coil is made up of a single conductor or of a relatively few conductors with only a moderate amount of insulation between them. When several coils or conductors are placed side by side, as in Fig. 3, it would appear at first glance that the middle coils should heat much more than the other ones; but in reality, unless there are many layers of coils, the temperature of the different coils will not vary greatly. For instance, in Fig. 3 the heat generated in the middle conductor is only one-third that of the total generated in the coils, and yet the two side surfaces through which the heat passes to the adjacent coil aggregate almost

as much as the total outside dissipating surface of the whole coil through which all the lateral heat flow is dissipated. Considering further that the insulation between the middle coil and its neighbor is relatively thin compared with the outside covering, it is obvious that the temperature drop from this coil to the adjacent one will be comparatively small—possibly not more than 10 per cent. of the drop through the outside insulation.

However, with a large number of coils side by side the conditions become cumulatively worse. Here the drop from the center conductors to the next one may be small, but the drop from the second conductor to the third is considerably greater, due to the heat of two conductors being transmitted. From the third to the fourth there is a drop corresponding to the losses of the three conductors, etc. Thus there is a gradual increased temperature drop from the center of the coil toward the outside surface, and if the coils be very deep—that is, if they consist of many layers—the sum total of the drop may be quite large. Or, putting it in another way, with a comparatively big coil the temperature rise from the outside surface of the coil itself toward the center will be very rapid at first and gradually taper off, as shown in Fig. 4. This is indicated very clearly in the case of an overheated field coil or coil of fine wire. Here the first outside layers will usually be found in fairly good condition, but at a comparatively little distance inside the coil there may be severe roasting or evidence of overheating, which may be almost as bad as at the center (see Fig. 5). In such a case the temperature measurement on the outside of the coil is no satisfactory indication of a hot-spot temperature. A temperature measurement by resistance, while a closer indication than that by thermometer, also may be very misleading. It may be stated that modern design tendencies are toward apparently shallow field coils, largely on account of this condition.

The whole object of this paper is to show the problem of temperature distribution and temperature measurements as it actually is. It is the writer's desire to show that no hard-and-fast rule can be made for determining the facts in each case and that the rules and methods now practicable are only approximate. The present limitations set for insulating materials are much higher than were considered practicable only a few years ago. This is not because the limits have been raised, but because through a better understanding of the facts the real upper limits of temperature as fixed by durability of insulation are now known to be considerably higher than was believed formerly to be the case.

If the real limits were in accordance with former beliefs, then all the evidence of the more accurate modern tests would indicate that the vast majority of the existing electrical machines should have "roasted out" comparatively early in their operation. The higher temperature limits were there, but were not recognized. Now we recognize them and attempt to make reasonable allowance for a difference between the measurable temperature and the actual hottest parts. The present method may be crude, but we are not going at it blindly, as was formerly the case. Formerly the manufacturer took the real responsibility for making a machine that was safe for the service, whatever the guarantee called for. Today the responsibility is still his, but he is attempting to educate the public to a knowledge of his real problem and to a recognition that temperature determination is far from being an exact art. There is no sharply defined line between good and bad in the insulating material as affected by temperatures; consequently, there is no sharp line between safe and unsafe temperatures.

American Society of Mechanical Engineers Annual Meeting

With the most extensive program and the largest registration in the history of the society, nearly 1,900, the thirty-seventh annual meeting of the American Society of Mechanical Engineers, on Dec. 8, closed a week of profitable technical discussion and enjoyable social activities.

The meeting was opened on Tuesday evening with an address by the retiring president, Dr. D. S. Jacobus, whose subject was "Education in Engineering." The speaker's previous long experience in the teaching profession rendered him well-qualified to speak on this subject. His observation had led to the conclusion that in the training of engineers the building of character and personality are more important than the acquiring of technical knowledge; next to this comes a thorough grounding in the fundamentals of engineering science. Summarizing, Doctor Jacobus made the following suggestions:

1. That there be closer coöperation between the engineering colleges and those employing graduates, and that the engineering societies be encouraged to work along this line.
2. That the technical requirements for entrance to colleges be lowered rather than raised; that preparatory schools be encouraged to give more attention to teaching good English and to giving a broad general education, and that applicants be also judged as to their initiative and general makeup in deciding whether they should be admitted.
3. That the courses be so arranged as to train the initiative and develop the human side; that the students be taught to work in a cheerful and efficient way; that there be proper time for daily relaxation of the minds and that the students be encouraged to use this time to the best advantage.
4. That the professors get down to hard work with their students and know each well enough to be thoroughly acquainted with his personal characteristics.
5. That the professors in practical engineering subjects have practical experience so they can speak with authority.
6. That professors be encouraged to undertake practical engineering work, and that their work be so arranged that they can be relieved from meeting classes when the engineering work makes this necessary.
7. That special attention be given to teaching the fundamentals of engineering science, even though this may result in the elimination of certain specialized branches.
8. That greater practice be given in the writing of concise and logical reports in good English and in speaking on one's feet.
9. That the students be encouraged to confer with the professors, and that regular hours be provided for this purpose, all to the end that the teachers may extend a helping hand where needed, and that there be a mutual understanding and trust.

The election of officers for the coming year was announced as follows: President, Ira N. Hollis; vice-presidents, Charles H. Benjamin, Arthur M. Greene, Jr., Charles T. Plunkett; managers, Robert H. Fernald, William B. Gregory, C. R. Weymouth; treasurer, William H. Wiley.

The new president was born at Mooresville, Ind., Mar. 7, 1856, and after graduating from the Louisville High School in 1872, became an apprentice in a machine shop. Two years later he entered the United States Naval Academy and later saw service on the cruiser "Quinnebaug," the "Alert," the "Hartford," the "Richmond" and the flagship "Charleston." In 1884 he served with the advisory board that designed the four ships of the White Squadron. He later served under George W. Melville in the Bureau of Steam Engineering, and in October, 1893, resigned from the Navy to become professor of engineering at Harvard University, where he remained for 20 years, resigning to take the position of president of Worcester Polytechnic Institute, which position he still holds.

In his speech, accepting the office of president, Doctor Hollis spoke of what he conceived to be the fundamental relation of the engineering profession to society. Quoting H. G. Wells, that "the history of mankind is the history of the attainment to external power," he expressed the desire that the work of the engineer might pass into the higher atmosphere of good will, service, and coöperation, in order that the profession may take its place alongside of the science of preventive medicine as one of the two constructive agencies in human life, and that we must serve as soldiers of peace in a country prepared to defend its home.

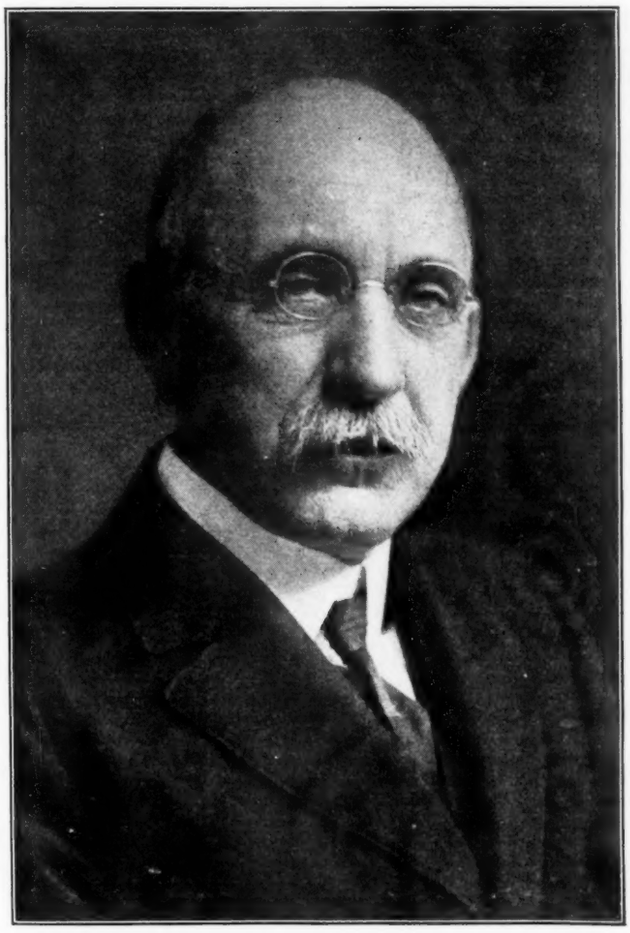
At the conclusion of the address a reception was tended by the president and the president-elect to the members and guests of the society in the ballroom of the Engineering Societies Building, which was followed by dancing and a collation. Over 700 attended.

At the business meeting on Wednesday morning the reports of the Council, standing committees and special committees were read, and the junior and student prizes were awarded. The former went to L. B. McMillan for his paper on "The Heat-Insulating Properties of Commercial Steam-Pipe Covering" (presented last year), and honorable mention was given Victor J. Azbe for his paper on "Power-Plant

Efficiency" and Herbert B. Reynolds for his paper, on the "Flow of Air and Steam Through Orifices." The student prizes went to B. M. Green, of Leland Stanford, Jr., University, for a paper on "Bearing Lubrication"; H. E. Stevens, of Rensselaer Polytechnic Institute, for a paper on "An Investigation of the Dynamic Pressure on Submerged Flat Plates"; and to M. Adam, of Louisiana State University, for a paper on "The Adaptability of the Internal Combustion Engine to Sugar Factories and Estates."

Following this, simultaneous sessions were held, at which papers were presented on: "The Proportioning of Surface Condensers," by George A. Orrok[1]; "The Testing of House-Heating Boilers," by Prof. L. P. Breckenridge and D. B. Prentice; "Water for Steam Boilers—Its Significance and Treatment," by Arthur C. Scott and J. R. Bailey; and a "Proposed Code of Safety Standards for Cranes," presented under the auspices of the subcommittee on Protection of Industrial Workers.

The following papers were presented by title only, as they had already been delivered at local section meetings:



PRESIDENT IRA N. HOLLIS

"Steam Safety Valves[2]," by George H. Clark; "Efficiency of Propulsive Machinery and Late Developments in Naval Engineering," by H. C. Dinger; "Standardization of Power-Plant Operating Costs[3]," by Walter N. Polakov; "Report of Efficiency Tests of a 30,000-Kw. Cross-Compound Steam Turbine[4]," by H. G. Stott and W. S. Finlay, Jr.; and "The Design and Test of a Large Reclamation Pumping Plant," by G. C. Noble.

Following the morning session memorial exercises were held in the auditorium in honor of the memory of John E. Sweet, past-president, honorary member and founder of the society.

On Wednesday afternoon a group of power-plant papers were considered. The first of these, "The Utilization of Waste Heat for Steam-Generating Purposes[5]," by Arthur D. Pratt, of the Babcock & Wilcox Co., dealt with the principles underlying the utilization of waste heat for steam-generation purposes and gave a general survey of what has been accomplished in this line. Even with comparatively low gas temperatures, a sufficiently high rate of heat transfer can be attained by the use of higher gas velocities, to make waste-heat boilers worth while, although this usually involves the use of induced-draft apparatus.

PROF. ALEX. G. CHRISTIE suggested that the increase of velocity which had been found so beneficial for waste-heat boilers might perhaps be used with advantage upon boilers in regular service, and referred to the work of Professor Nicholson, in England, in this direction.

WARREN B. LEWIS, consulting engineer, Providence, R. I., told of an installation put in by his advice in which the waste gases from furnaces fed by producer gas from bituminous coal were used. The temperature of the gases averaged 1,050 deg. F., and the boilers were designed to abstract 550 deg. They did reduce the temperature to 418 deg. with 6,600 sq.ft. of heating surface. The transfer rate was less than two B.t.u. per square foot per degree difference. The amount of gas available was not given, but about 8,400 tons of coal were burned per year. The fan for artificial draft consumed about 2½ per cent. of the net return from the boilers.

B. N. BRODIO said that waste heat is often used in Germany to superheat steam. Independent superheaters make an ideal installation. He had designed a number of such installations, one for 66,000 and another for 40,000 lb. of steam per hour with a velocity of the flue gases of about 900 ft. per min. and a velocity of steam inside of the pipes of about 5,000 ft. per min. the average heat transfer was about 4.3 B.t.u. per sq.ft. per deg. difference. On account of its smaller heating surface, the cost of the independent superheater was considerably smaller than would have been the case had each boiler been provided with its own superheater. He announced that detailed results of a test with a similar superheater, together with a description of the superheater, will be published in "Power" shortly. Most of the superheaters have been installed for waste heat from coke ovens and openhearth steel furnaces. Copper furnaces and cement kilns are also available sources.

DR. L. D. RICKETTS, New York, said that the Cananea plant is the oldest in which the header type of flues for the distribution of waste heat to boilers was used. The new plant of the International Smelting Co. near Globe, Ariz., has three reverberatory furnaces and seven waste-heat boilers of a capacity of 713 hp. each, supplied with superheaters that furnish 50 deg. of superheat to the steam, which is generated at 195 lb. They find it advantageous, however, to use three boilers to a furnace. Each furnace has a capacity of about 500 tons of solid charge per day, and with two furnaces running continuously, the plant smelts about 30,000 tons of solid charge per month. The amount of water evaporated from and at 212 deg. in the oil-fired boilers in the power house is 16.46 lb. per lb. of oil. The amount of water evaporated from and at 212 deg. for each pound of oil burned in the reverberatory furnaces is 7.23 lb. In other words, a pound of oil burned for smelting purposes in the reverberatory furnaces yielded in addition an average of 44.77 per cent. of the power such oil would yield if burned under its boiler.

ANALYSIS OF POWER-PLANT PROBLEMS

The paper of R. J. S. Pigott on "Graphic Methods of Analysis in the Design and Operation of Steam Power Plants" was next taken up. This paper, an abstract of which will appear in an early issue, proposes the more extended use of graphic methods of analysis of the problems involved in power-plant design and operation. Such methods have two distinct applications—in the design of new power plants when they are based upon anticipated load curves only, and in the operation of existing plants to determine the efficiency of operation from plant records. The author illustrated his theme by an example of each application, using the data guaranteed by the makers of apparatus for the 90,000-kw. addition to the Seventy-Fourth Street Station of the Interborough Rapid Transit Co. of New York for the first and the operating data from the power plant of the Remington Arms and Ammunition Co., Bridgeport, Conn., for the second. The individual input-output lines for the main units, boilers and auxiliaries are combined to obtain input-output lines for the engine room and complete plant. The effects of modifying the operating conditions of the plant and of changing the character of the auxiliary equipment were presented in an interesting manner by means of the graphic analysis. From an analysis of the curves, the cost of producing power for given conditions may be determined with little effort and the effects of changes in the conditions or equipment may be predetermined with accuracy. The author believes that the adop-

[1]This paper was abstracted in December 5, "Power."
[2]See "Power" Jan. 11, 1916.
[3]See "Power" Feb. 2, 1916.
[4]See "Power" May 23, 1916.
[5]See "Power" Dec. 12, 1916.

tion of graphic methods will not only shorten the labor in power-plant design, but will reduce the chances of error and encourage a rigorous heat analysis. The paper evoked an extended discussion, which will appear in these columns in connection with the abstract of the paper.

The next paper, upon "Power Plant Efficiency," by Victor J. Azbe, received honorable mention in the junior prize contest.

This paper calls attention forcibly to the preventable waste in power-plant operation. It characterizes fuel-loss prevention as a national problem affecting the welfare of our descendants and the ability of the American nation to be a world power and commercial leader. It not only advocates the examination and license of engineers, but extends the ground for such action to the conservation of national resources and the promotion of national efficiency, which might perhaps warrant a better law upon the subject. So far as we know, it was the first word that has ever been spoken upon the floor of the American Society of Mechanical Engineers in favor of an engineer's license law, and not a voice was raised against it. The paper concludes with a recommendation that "The American Society of Mechanical Engineers start the movement by forming a committee for the prevention of fuel losses and general betterment of power-plant conditions, which would devise ways and means by which the best results could be obtained," and it was voted that the Council be requested to appoint a committee for this purpose. The paper, with its discussion, will appear in abstract in an early issue.

NINETY PER CENT. BOILER EFFICIENCY

During the course of the discussion E. N. Trump, of the Solvay Process, at Syracuse, created a sensation by claiming that they were getting a sustained over-all, day in and day out, efficiency of 90 per cent. in their boiler plant. This it should be understood includes the economizers, etc. It includes, however, coal used for all purposes, although, as the operation is continued, there is little burned that does not appear in the output.

At the same session papers were presented upon the "Impact Tube," by Sanford A. Morse, of the General Electric Co., at Lynn, Mass., and "The Flow of Air and Steam Through Orifices," by Herbert B. Reynolds.

The papers presented at the Textile Session were as follows: "Heat Transmission Through Various Types of Sash," by Arthur N. Sheldon; "Spontaneous Ignition Studied by Means of Photographic Plates," by Frederick J. Hoxie; and "Vibration in Textile Mill Buildings," by G. H. Perkins.

The Machine Shop Session included the following papers: "Standardization of Machine Tools," by Carl G. Barth, and "A Proposed Plan for the Activities of the Machine-Shop Practice Subcommittee of the American Society of Mechanical Engineers," by H. K. Hathaway.

The Valuation Session occupied all of Thursday morning and part of Thursday afternoon, five papers in all being presented: "Accurate Appraisals by Short Methods," by J. G. Morse; "How Does Industrial Valuation Differ From Public-Utility Valuation?" by John H. Gray; "Relation Between Perpetual-Inventory Value and Appraisal Value," by Charles Piez; "Valuation of Industrial Properties vs. Valuation of Industrial Methods," by Walter N. Polakov; and "Productive Capacity a Measure of Value of an Industrial Property," by H. L. Gantt. The two last-named papers pointed out that the valuation of industrial properties is less important than the valuation of industrial methods.

Simultaneous with the second Valuation Session was the Gas-Power Session, held under the auspices of the subcommittee on gas power. O. C. Berry dealt with a producer of the recirculated gas type for bituminous coal. While not claiming originality for the type of producer, the author gave the results of investigations to determine the most effective form of steam blower to maintain the circulation while supplying the steam necessary in the gas-evolving process; the proper range of temperature for the recirculated gas; the lower limit for the temperature of the coal at the top of the fuel column to avoid troubles from tar; and the lowest temperatures at which one may be sure that the last trace of tar has been driven off from the coal. He found that the proper temperature for the recirculating gases to precipitate the least tar was between 300 and 450 deg. C. In describing the recirculating producer he offered the following recommendations:

1. That the plant be simple in construction.
2. That all parts of the fuel column must be readily reached by the poker.
3. A ready means must be provided for cleaning out the clinker and ash.
4. The air and recirculating gas must enter evenly over the entire area of the bottom of the fuel column.
5. The steam must be evenly distributed through the air for combustion.
6. The air must be equally free to circulate in all parts of the fuel column.
7. The gas must be so taken from the producer as to cause an even circulation through the upper part of the fuel column.
8. The gas furnished by the producer must be entirely free from tar at all times.

H. F. SMITH in discussing the paper expressed the opinion that with this type of producer there was not enough coke produced unless the coal has a high percentage of fixed carbon.

The next paper was on "The Commercial Sampling and Analysis of Producer Gas," by P. W. Swain, who expressed the opinion that the quality of the gas may usually be judged from the percentage of carbon dioxide present, and proceeded to discuss methods of sampling the producer gas and apparatus for making the analysis.

In discussing the paper H. F. Smith cited figures to show that the percentage of CO_2 is not indicative of the heat value of the producer gas. Of a number of analyses made at the same plant, and by the same man, several with identical percentages of CO_2 showed greatly varying heat values, and others with identical heat values showed varying Co_2.

The next paper was on "The Ratio of the Specific Heats and the Coefficient of Viscosity of Natural Gas from Typical Fields," by Robert F. Earhart.

This was followed by "An Investigation of the Internal-Combustion Engine as Applied to Traction Engines," by A. A. Potter and W. A. Buck, who pointed out that the importance of this type of engine is evidenced by the fact that more than a hundred concerns are now engaged in building traction engines for farm use. These engines range from 15 to 60 hp. in capacity and, when working at full load, require about three-quarters of a pint of gasoline per horsepower-hour. The increasing price of this fuel has stimulated investigation and experiment with cheaper petroleum products, and it has been found that an equal quantity of ordinary kerosene, costing in the neighborhood of half what gasoline does, will do the same work.

The final paper of the Gas-Power Session was "A Review of the Development of the Werkspoor Marine Diesel Engine," by Thomas O. Lisle. This was illustrated by lantern slides, the author pointing out many features of design which had been the outcome of attempts to overcome earlier defects in the oil engine. He pointed out the inherent advantages of the four-stroke-cycle engine, and among the most interesting designs shown was one recently furnished to the Netherlands Navy.

CONDITION OF THE NAVY

On Friday morning Prof. W. L. Cathcart, of Philadelphia, gave an "Illustrated Review of the Development of our Fleet and Naval Stations." He dwelt upon the ease with which a foreign power could seize important American ports, and the vital necessity, if the Monroe Doctrine is to be upheld and the Panama Canal protected, of our mastery of the Caribbean Sea, the importance of fortifying Guam and Hawaii, and the needs of our Navy Yards.

In discussing Professor Cathcart's paper Rear-Admirals Bradley A. Fiske and John R. Edwards spoke plainly of the inefficient way in which our naval defenses have been handled. "South of Hatteras," said Admiral Edwards, "we haven't a crane that will lift a gun out of the turret of a battleship, and it is a fact that there is no place along the coast south of that cape where a battleship could go for repair if it were crippled in action." An adequate base at Charleston he believed would make an enemy extend its line of operation from 500 to 600 miles. Speaking along similar lines, Admiral Fiske said that the American people do not realize their danger any more than does a baby on a railroad track. "Power and duty always go together," he said. "Since you men here assembled have the power to accomplish important things, it is the duty of every member of this society to point out to his fellow citizens our danger. The Caribbean Sea has, for its size, more strategic positions than any other important expanse of sea on the Globe. For the United States its mastery in war is almost vital, since that mastery is the bulwark of our defense in the Monroe Doctrine and of the Panama Canal."

This discussion was followed by a paper on the "Heat Treatment of Wrought-Iron Chain Cable," by F. G. Coburn, W. W. Webster and E. L. Patch.

Simultaneous with this session was the Railroad Session under the auspices of the subcommittee on railroads, at which three papers were presented: "Clasp Brakes for Heavy-Passenger-Equipment Cars," by T. L. Burton; "Mechanical Design of Electric Locomotives," by A. F. Batchelder; and "Pulverized Fuel for Locomotives," by J. E. Muhlfeld.

A Steam Boiler Session was also held on Friday morning under the auspices of the Boiler Code Committee. "An Analysis of Marine Safety Valves with Suggestions for Repairs and Improvements," by E. F. Maas, seems to be of general application with regard to safety valves, and will be considered in a later issue.

"The Talbot Boiler," by Paul A. Talbot, describes a type of boiler in which the flow is downward through double free-ended pipes somewhat after the Niclausse construction, and for which the remarkable claim is made that a tube was removed under 250 lb. steam pressure and replaced by another tube in 61 sec., the total period between the time of shutting off the fire and feed water and the time of regaining full pressure and maximum capacity being 3 min. 16 sec. The boiler was described in "Power" of Apr. 1, 1913.

John Clinton Parker, of Philadelphia, read a paper on the downflow type of steam boiler, dealing with the type in general and with the Parker boiler in particular.

The remainder of Friday and Saturday was devoted to a hearing by the Boiler Code Committee of those who desired modifications in or interpretations of the Boiler Code. The only feature that developed important discussion was the welded joint. The autogenous-welding people, representing both the electrical and flame processes, were out in force to protest against the complete exclusion of the welded joint from use on high-pressure boilers. Deputy Inspector Luck, of Massachusetts, objected to the use of cast steel for water-leg and door-frame rings of vertical fire-tube boilers 36 in. and over in diameter, asked for an additional row of hand-holes at the water level in vertical fire-tube boilers and a requirement of extra-heavy valves and fittings when the pressure exceeds 100 lb., instead of 125, as the Code reads at present. The steam manufacturers asked that the specification with regard to copper contents be left out of the specification for firebox steel, and for a range of 10,000 lb. instead of the 8,000 lb., as at present allowed.

Mr. Young renewed the representations of the American Society for Testing Materials for representation upon the committee, with voting power. Mr. Keuen, of the Badenhausen Boiler Co., asked that the sheets be stamped at the tensile strength at which the test pieces actually fail, rather than at 55,000 lb. arbitrarily. The steel makers objected to this as being impracticable. Prof. M. T. Cooley, dean of the Departments of Engineering and Architecture of the University of Michigan, objected to the use of lap joints, even for shells less than the 36 in. diameter with which lap joints are now allowed by the Code, and also objected to the use of such joints for furnace tubes. The board listened attentively to all of the arguments presented, but took no part in the discussion, and it is not likely that very serious revisions of the Code will result.

This year the society reverted to the practice of having noonday luncheons served in the building from 12:30 to 2, which gave members an opportunity to meet and hold informal reunions. The wisdom of this step was shown by the large attendance at these luncheons.

EXCURSIONS AND SOCIAL FEATURES

Of almost equal importance with the technical sessions were the excursions to places of interest in the vicinity. These were largely attended and included a trip to the Walker Street Telephone Building of the New York Telephone Co., which houses some of the latest telephone and telegraph equipment, and through which all the toll calls pass. The Equitable Building at 120 Broadway was also visited, as an example of one of the most uptodate office buildings in the city.

On Thursday excursions were conducted to the plants of the Otis Elevator Co., at Yonkers; the Stevens Milk Co., Third Ave., Brooklyn, where an uptodate gas-power plant was inspected; the new Essex Power House of the Public Service Co. of New Jersey[6]; and the Loose-Wiles Biscuit Co., Long Island City.

On Friday a party visited the new plant of the New York Steam Co., wherein 24,000 boiler horsepower will furnish commercial steam to the downtown section in New York for both heating and power. As usual, the excursion to the Brooklyn Navy Yard was largely attended, about 125 members and guests taking this in.

Social features, in addition to the President's Reception, included a get-together smoker on Wednesday evening, which about 850 attended. Frank B. Gilbreth gave an amusing and instructive talk on his experiences through the war zone in Europe, and this was followed by a troupe of professional entertainers.

A reception and tea for the ladies was held, as usual, on Wednesday afternoon.

[6]Described in "Power" for Nov. 28, 1916.

Instead of the customary formal dinner and dance at the Hotel Astor, the Thursday evening affair consisted of a Symposium on Aviation by a number of well-known authorities on aviation; these talks being illustrated by lantern slides and moving pictures, one of which showed recent flights of the original Langley machine. After the lecture the members and guests adjourned to the fifth floor, where a reunion and dance was held. The large attendance attested to the popularity of the affair.

On Friday evening, as usual, were held the college reunion dinners. These included Brown University, Cornell University, Lehigh University, Massachusetts Institute of Technology, Pennsylvania State College, Polytechnic Institute of Brooklyn, Stevens Institute of Technology, University of Illinois, University of Michigan, Worcester Polytechnic Institute, and Purdue University.

Meeting of American Society of Refrigerating Engineers

On Dec. 4, 5 and 6 the American Society of Refrigerating Engineers held its twelfth annual meeting at the Engineering Societies Building, 29 West 39th St., New York City. President Theodore N. Vilter, of the Vilter Manufacturing Co., Milwaukee, Wis., presided. Reports show the society to be progressing favorably in membership.

Monday afternoon Dr. Hermann Dannebaum read a paper, "Data on the Ammonia and Water Mixer Specified by the Refrigeration Regulations of New York City."[1] Readers will recollect that in this mixer the refrigerant, say ammonia, enters through a small pipe into a chamber made of larger pipe wherein the ammonia mixes with incoming water, both going to the sewer. The refrigerant pipe has $\frac{3}{32}$-in. holes for letting the ammonia into the larger pipe. At the time of the passage of the New York rules, criticism was made to the effect that these holes would scale or otherwise tend to become stopped. Doctor Dannebaum practically confirmed this criticism.

For the last three yearly meetings R. H. Coffey and George A. Horne have read papers, or, rather, continued a paper, on the "Theory of Cooling Towers Compared with Results in Practice." This year's installment ended an exceedingly interesting and valuable paper. Now that the paper is complete, "Power" will soon abstract and publish it. Following Messrs. Coffey and Horne's paper, Enoch Rector described his extended heating-surface boiler.[2]

Monday evening was Bureau of Standards night, there being three papers by representatives of the bureau. E. C. McKeloy and C. S. Taylor had a paper on "Chemical Analysis and Testing of Commercial Ammonia." Most of this chemical tested was of American make, though some of German manufacture was included. Dr. R. S. Harper read an interesting paper on "Progress in Measurements of Physical Properties of Ammonia at the National Bureau of Standards." This was in the nature of a review of what has been done since the bureau outlined the refrigeration program five years ago. Dr. H. C. Dickinson and N. S. Osborn, of the bureau, had a paper on the "Specific Heat and Latent Heat of Anhydrous Ammonia." This was for the most part a continuation of a paper read at a previous meeting.

The bureau's papers showed what a considerable amount of detail was involved in the extensive research work undertaken by it. Doctor Harper said that practically nothing had been done in investigating the properties of aqua ammonia, pointing out that there was more immediate need of attention to anhydrous, and that while work on the latter was difficult enough, it was much more difficult on aqua ammonia owing to two liquids being involved in the solution.

In the absence of Charles Hillop, author of a paper on "Oxyacetylene and Electric Welding," President Vilter read the paper. The discussion of this subject will be included in a separate article, soon to be published, setting forth the status of opinion on welding for pressure vessels as brought out in discussion at the yearly meetings of both the American Society of Refrigerating Engineers and the American Society of Mechanical Engineers.

The paper on "Low-Temperature Compression System," by Harry Sloan, was read by President Vilter. This paper will soon appear in "Power."

Tuesday evening those in attendance enjoyed a beefsteak dinner at Murray's.

Considerable interest was shown in a paper by John E. Starr, on "Accidents in Refrigerating Plants." The paper was

[1]Described in "Power," June 27, 1916, p. 932.

[2]Described in "Power," May 2, 1916.

statistical and aimed to cover the causes of accidents in refrigerating plants from 1910 up to the present. Mr. Starr was of the opinion that the ratio of accidents to the number of machines and men involved is no greater than in other industries. Of over 1,100 welded pressure vessels installed, but nine had failed. Approximately 40 per cent. of the accidents were due to ignorance and carelessness on the part of operators; 14 per cent. are chargeable to original defects in the machinery. Another 14 per cent. are due either to defects in machinery or to neglect—it is difficult to tell which. The danger of testing with air is shown by the fact that 5½ per cent. of the accidents are due to the air vaporizing the oil in the system and creating an explosive mixture. It is rather surprising that approximately 14 per cent. are the result of receivers and other vessels bursting because filled with liquid ammonia, which, on the application of room temperature, expands; the vessels were, of course, shut off so that the liquid had no escape. The remaining percentage of causes was not ascertained. It appears that Mr. Starr's paper, besides being valuable indeed for the information it sets forth, was of appreciable force in causing the society to more deeply appreciate the necessity of formulating a safety code.

Wednesday morning F. L. Fairbanks read his paper, dealing, chiefly in a descriptive way, with the booster compressors in his Richmond Street (Boston) plant. A description of this installation was written by one of "Power's" staff after visiting the plant and appears in the Aug. 15, 1916, issue, p. 228. Mr. Fairbanks' paper appears in the society's "Journal" for December.

Prof. R. C. Carpenter read a short paper on balsa wood, a Central American product intended, as one of its many uses, for refrigeration insulation. This wood weighs but a trifle over 7 lb. per cu.ft.—cork weighs over 13 lb. per cu.ft. The greatest objection to it seemed to be its inflammability when not treated with a preventive. It also is treated for moisture with paraffin.

The spring meeting will likely be held at Milwaukee. N. H. Hiller is the new president.

ENGINEERING AFFAIRS

The New England Water-Works Association held a meeting in Boston on Dec. 13, with headquarters at the Hotel Brunswick.

The Philadelphia Section of the Association of Iron and Steel Electrical Engineers will hold a meeting on Jan. 6, at the Majestic Hotel.

The Pittsburgh Section of the Association of Iron and Steel Electrical Engineers will hold a meeting on Jan. 20, at the Fort Pitt Hotel.

The Detroit Engineering Society will hold a meeting on the evening of Dec. 20. Fred J. Griffiths, vice-president and general manager of the Central Steel Co., of Massillon, Ohio, will speak on "The Manufacture of Vanadium Steel."

The Blue Room Engineering Society will hold its regular monthly meeting during the month of December on the third Thursday of the month, or Dec. 21, instead of the second Thursday as customary. Final nominations and election of officers will take place.

The Detroit Chemists will hold a joint meeting with the Detroit Engineering Society on the evening of Dec. 21, on the sixth floor of the Stevens Building. Dr. R. Winthrop Pratt, consulting engineer of the City of Cleveland, and Dr. Hippolyte Greuner, professor of chemistry of Western Reserve University, will speak on "The Proposed Method of Water Purification at Cleveland."

The Marine Engineers' Beneficial Association, No. 33, of New York City, held its annual entertainment and ball at Lexington Opera House on Dec. 6. The attendance was, as usual, large, and many prominent engineering folks were present. Dancing followed a good vaudeville entertainment. The arrangement committee comprised F. J. Steele, H. L. Jauss, James Moran, Thomas Quigley, Alfred St. James, Richard Aiken, Thomas Delahunty and William Warrington. Frank Martin, of Jenkins Bros., was the floor director.

The Washington Society of Engineers held its annual dinner at Rawscher's Hall, Dec. 5, 1916. The affair was attended and heartily enjoyed by 275 members and guests. The speakers were John C. Hoyt, president of the society, toastmaster; Hon. Newton D. Baker, Secretary of War; Hon. Wendell P. Stafford, associate justice, District Supreme Court; Dr. L. H. Baekeland, member Naval Consulting Board; Rev. Dr. Abram Simon; Louis Garthe, journalist; Frank C. Wight, managing editor, "Engineering News." The musical program was under the direction of John S. M. Zimmermann. The annual meeting of the society for election of officers will be held Tuesday evening, Dec. 19.

The American Association for the Advancement of Science will hold its sixty-ninth meeting in New York City from Dec. 26 to 30, 1916. The registration headquarters will be at Earl Hall, Columbia University, and will be open on Dec. 26, after 9 a.m. Most of the meetings of the sections of the association and of the national affiliated societies will be held at Columbia University. The Engineering section will hold a session in the Engineering Societies Building, on the invitation of the American Society of Civil Engineers, the American Institute of Mining Engineers, the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers. At this meeting, Bion J. Arnold will give the address of the retiring chairman, and there will be addresses by representatives of the engineering societies, followed by a reception to engineers and those working in sciences related to engineering.

Engineers of Three States to Form a Society—A. F. Barnes, Dean of Engineering, of the New Mexico College of Agriculture and Mechanic Arts, State College, N. M., has been endeavoring to organize a Southwestern Engineering Society. Letters have been received from prominent engineers in the three states of New Mexico, Arizona and Texas expressing the need of such an organization. Admission to this society will no doubt not only be open to practicing engineers, but opportunity to join will be given to any person so connected with engineering as to qualify him to coöperate with engineers in the advancement of professional knowledge. It is planned in a short time to call a meeting of those engineers that have shown interest in the matter.

Proposed Construction

Ill., Gibson City—Board of Local Improvements making plans for electric-light and water plant. Receiving bids Apr. 1. About $30,000. Melluish & Broyhill, Unity Building, Bloomington, engineer.

Ill., Granite City—Public Utilities Commission granted Madison County Light and Power Co. permission for transmission line from Granite City to Nameoki.

Iowa, Nora Springs—Nora Springs Light and Power Co. plans improvements.

Maine, Islesboro—Islesboro Inn making plans for power house in Dark Harbor District. Evans & Warner, Witherspoon Building, Philadelphia, Penn., architect.

Mass., Weymouth—Weymouth Light and Power Co. plans extending distributing system.

N. J., Newark—Board of Public Works considering electric-light plant and power station on Elizabeth Ave.

N. Y., New Lebanon—Albany Southern Railroad Co. plans extending transmission line from Brainard to New Lebanon. G. F. Silvia, Rensselaer, chief engineer.

N. Y., Rushford—Cuba Electric Co. plans extending transmission line.

N. D., McHenry—City voted bonds to build electric-light plant.

Ohio, Athens—Ohio State Hospital made application to State Board of Administration for appropriation for power plant and other improvements. About $50,000.

Ohio, Cleveland—Ward Baking Co. plans power house on Perkins Ave. C. B. Comstock, 110 West 49th St., New York, architect.

Ohio, Monroe—Middletown Gas and Electric Co., Middletown, plans extending transmission line to Monroe.

Okla., Collinsville—Commissioners making plans for extending electric-light plant.

Penn., Ambridge—Duquesne Light Co., Pittsburgh, purchased site at Ambridge and plans substation. F. Uhlenhaut, Jr., Pittsburgh, chief engineer.

Penn., Tunnelton—Bessemer Coal and Coke Co. making plans for one-story, 44x101-ft. substation. Randolph Means Co., Oliver Building, Pittsburgh, engineer.

S. D., Lesterville—Council plans election to vote on $18,000 bonds to build electric-light plant.

Tex., Marlin—Marlin Ice and Electric Co. plans extending and improving electric-light plant.

Tex., Newcastle—Newcastle Light and Power Co. granted franchise for electric-light plant.

Vt., Barre—Central Power Co., recently organized to develop water powers on Middlebury River and branches, applied to Council for franchise for transmission line into Barre.

Va., Franklin—City plans voting on $40,000 bonds to improve electric-light system.

Va., Richmond—Virginia Railway and Power Co. granted permit for 13 500-volt transmission line to connect with American Locomotive Works.

W. Va., Clarksburg—Monongahela Valley Traction Co., Fairmont, and Clarksburg Light and Heat Co. plan transformer station in Clarksburg.

Wis., Milltown—Town granted A. O. Dahlberg, Clam Falls, franchise for electric-lighting system for period of 25 years.

Wis., Thorp—Wisconsin-Minnesota Light and Power Co. plans extending transmission line to Thorp. J. H. Brewer, Grand Rapids, Mich., president.